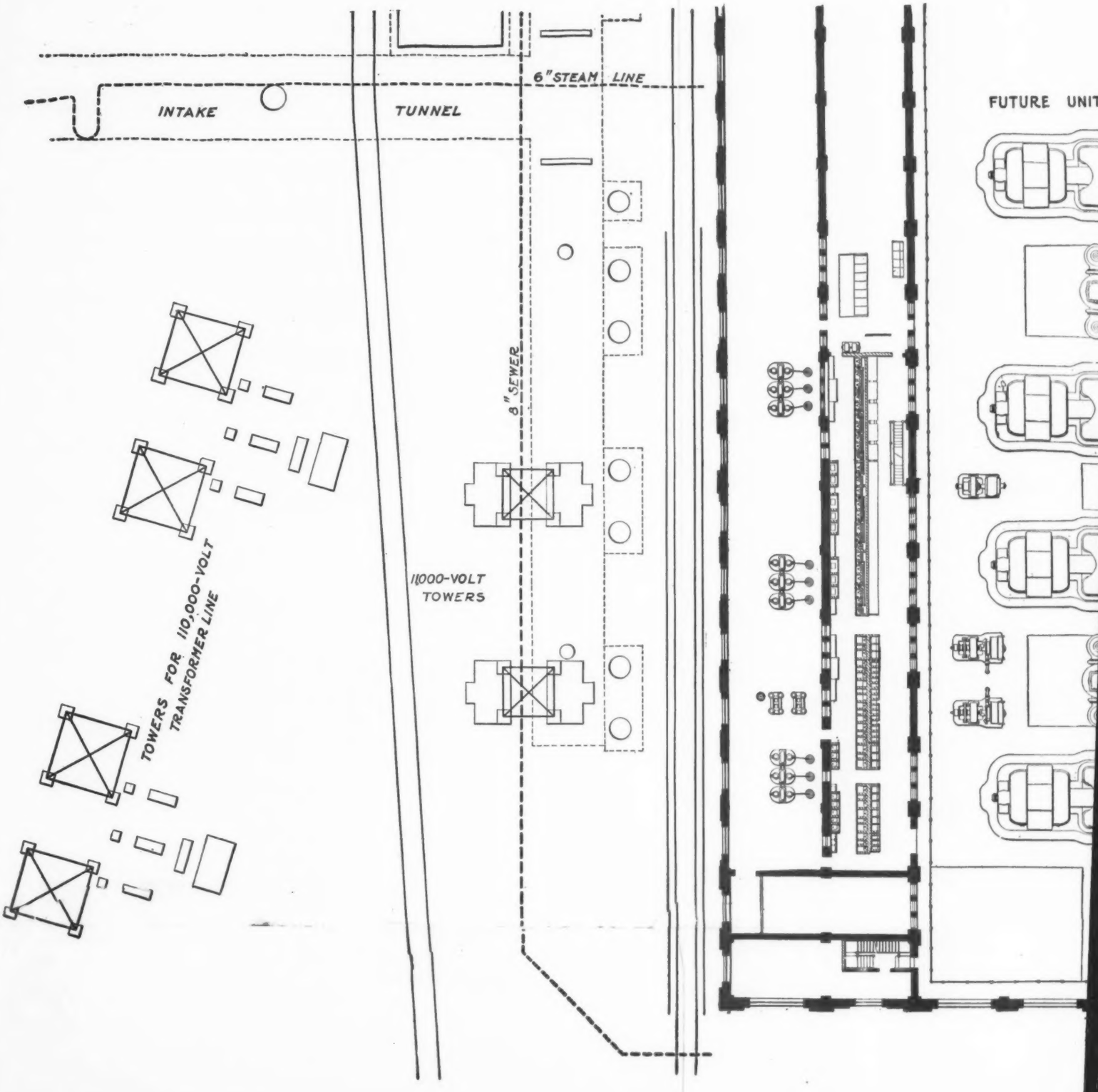


FIG.

PLAN AND ELEVATION O
POWER PLANT OF THE
ELECTRIC CO.

ULTIMATE BOILER CAPACITY, AT LEAST 32,000 HP.
IN 32 UNITS, AND 100,000 KW. IN TURBINE CAPACITY,

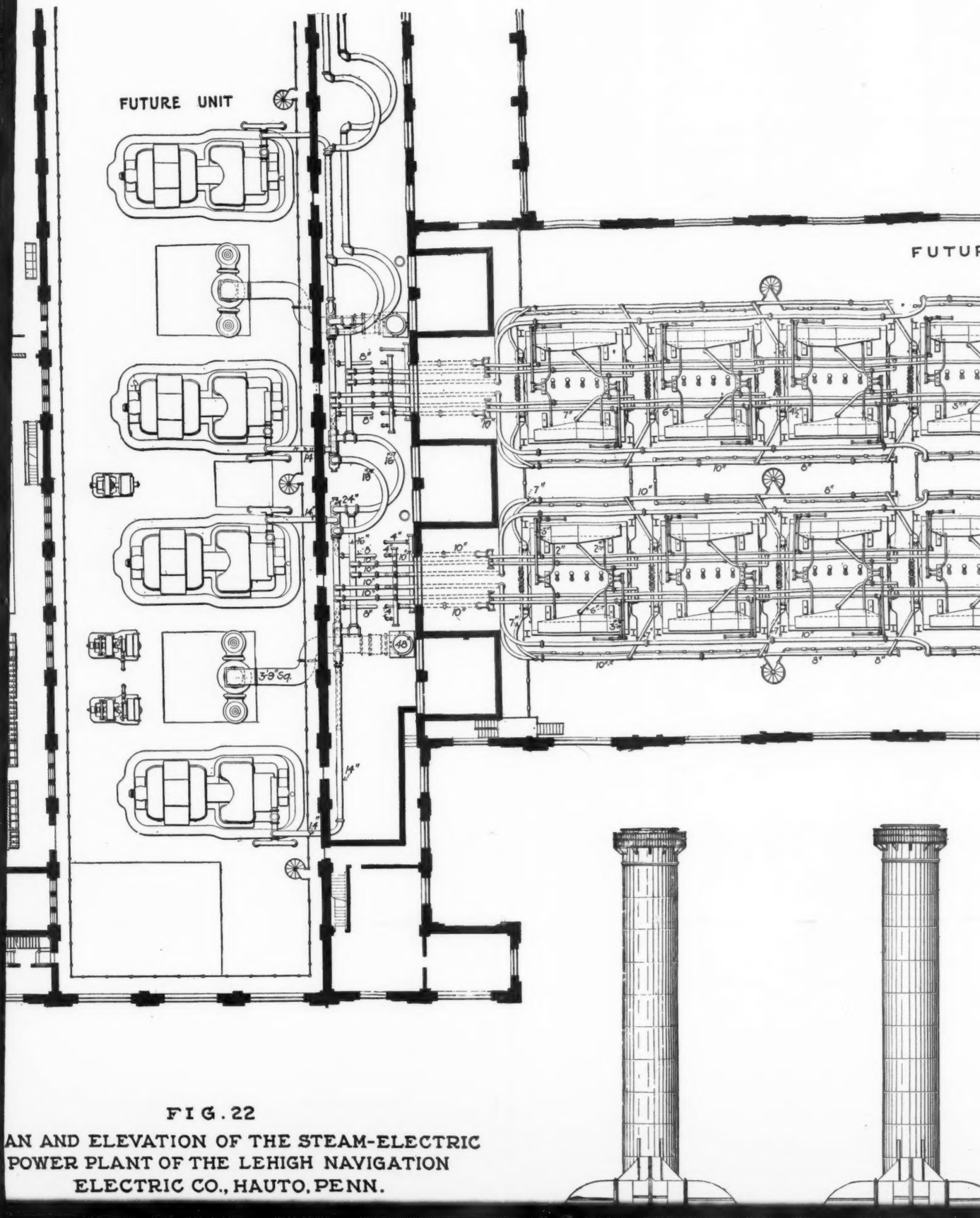
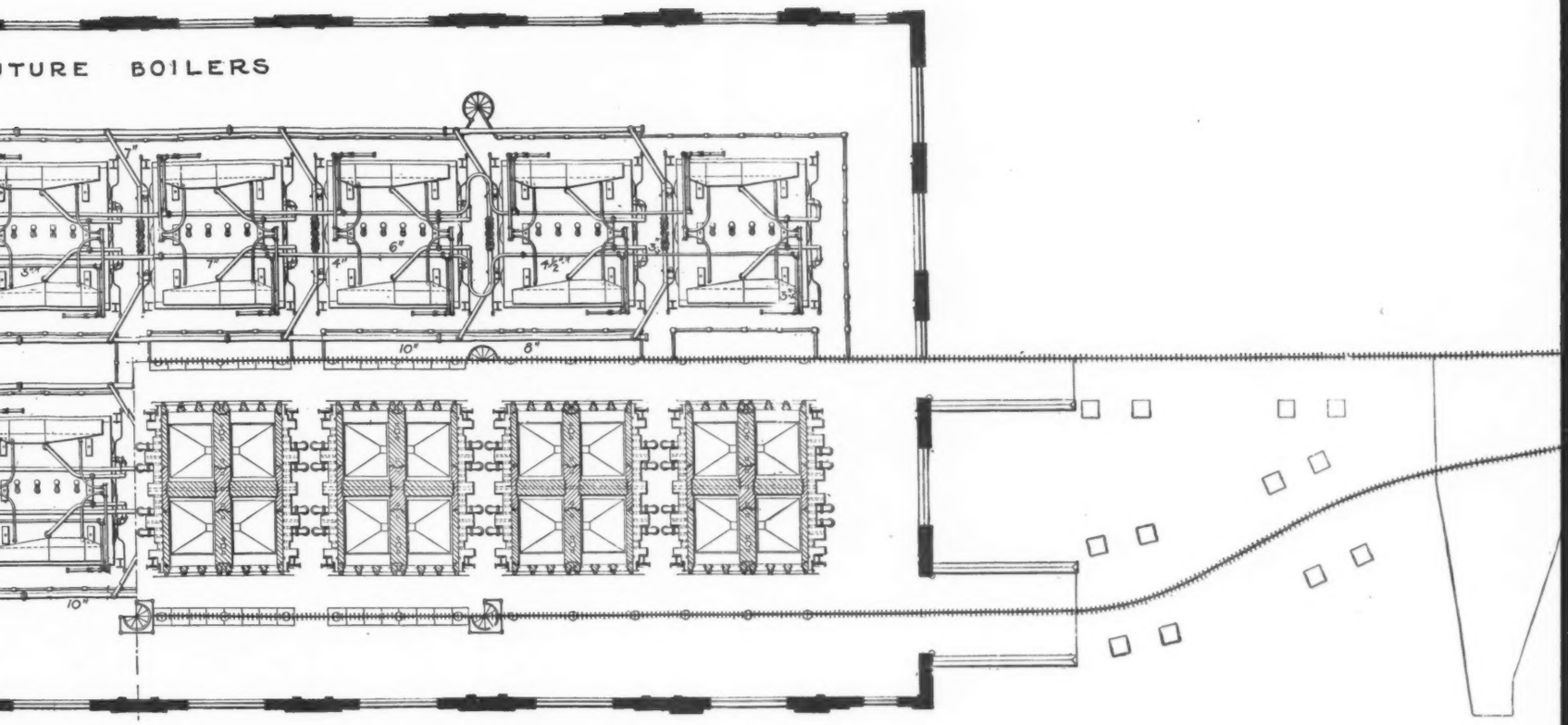
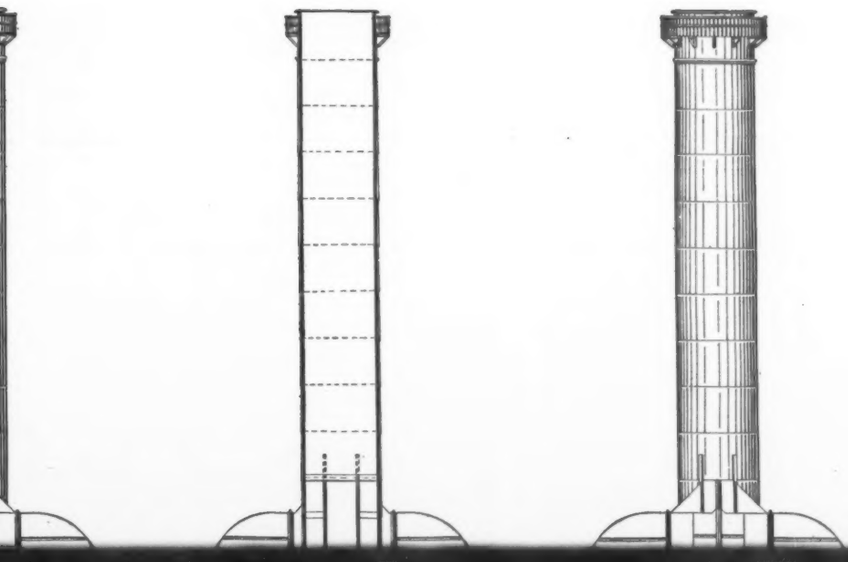


FIG. 22

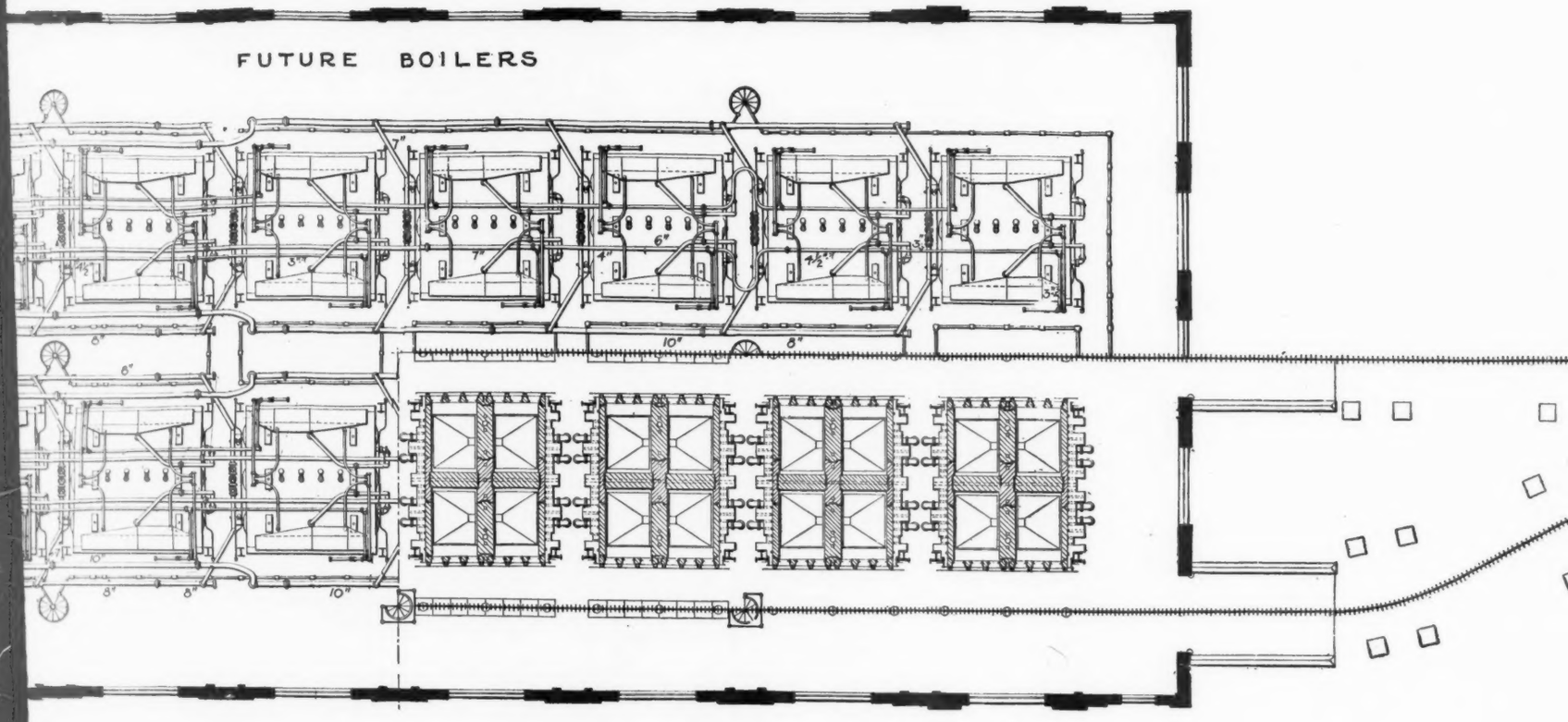
AN AND ELEVATION OF THE STEAM-ELECTRIC POWER PLANT OF THE LEHIGH NAVIGATION ELECTRIC CO., HAUTO, PENN.

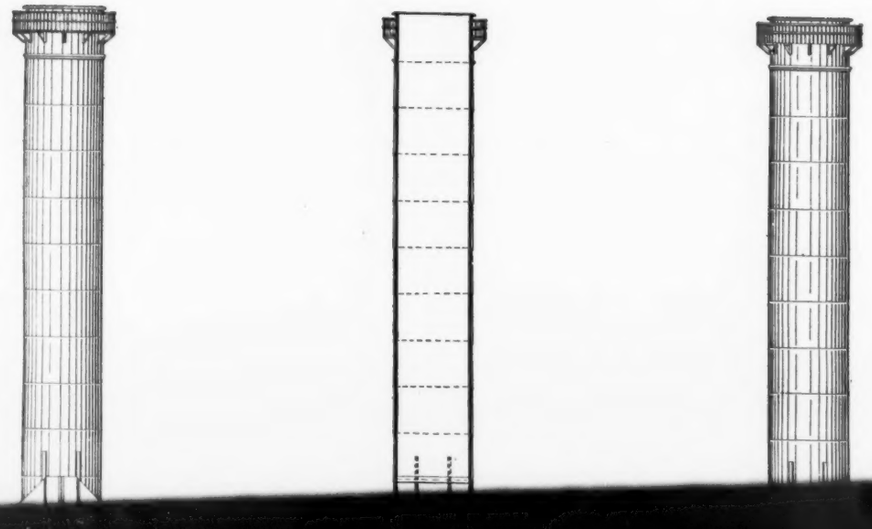




0 10′ 20′ 30′ 40′ 50′ 60′

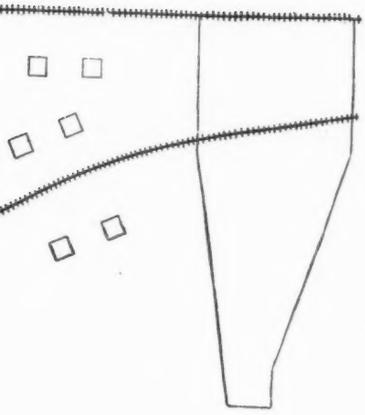
SCALE





0 10' 20' 30' 40' 50'

SCALE

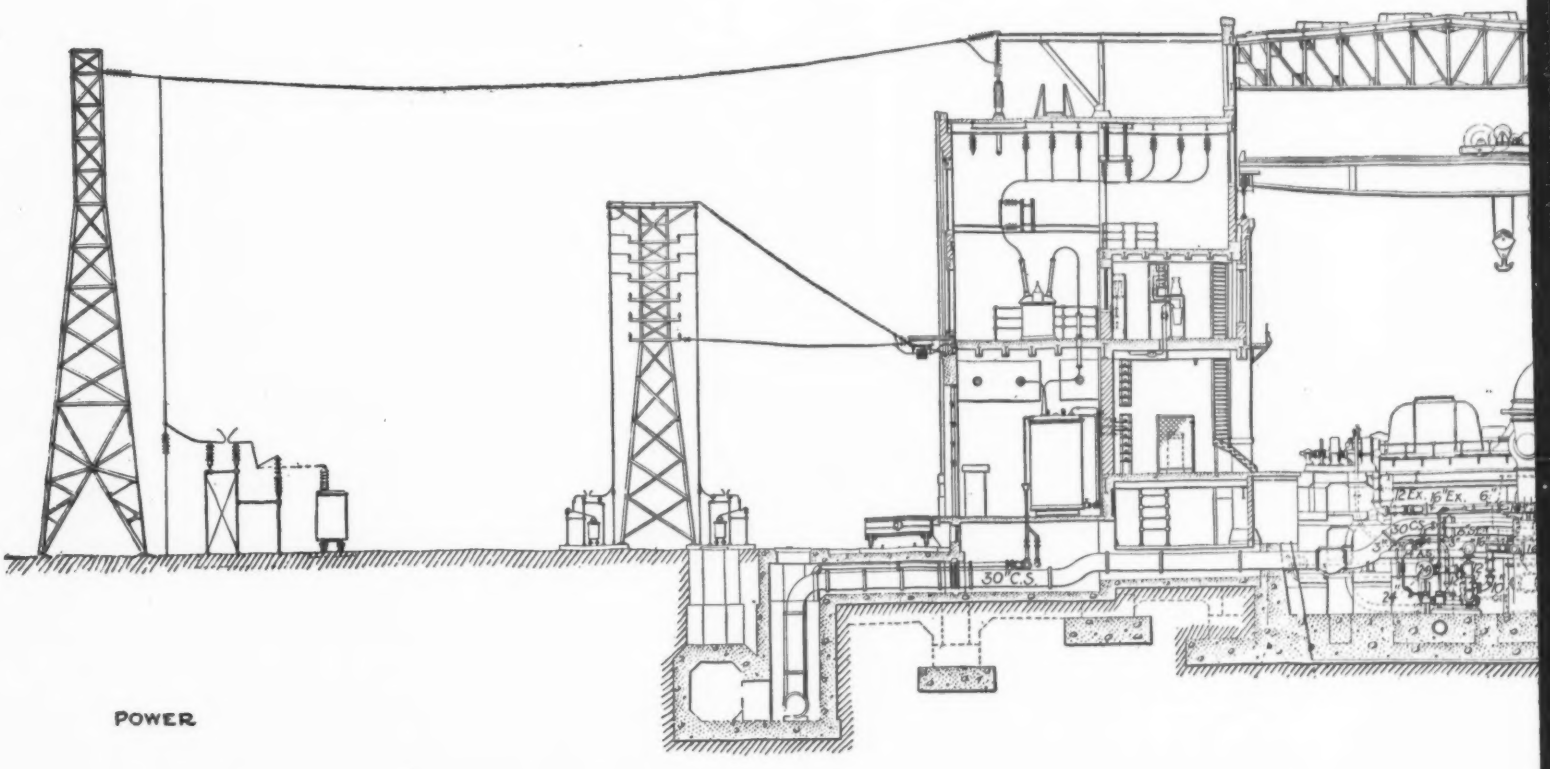


50' 60'

FIG. 2

PLAN AND ELEVATION OF
POWER PLANT OF THE
ELECTRIC CO., H

ULTIMATE BOILER CAPACITY, AT LEAST 32,000 HP. IN 32 UNITS, AND 100,000 KW. IN TURBINE CAPACITY, EXCLUSIVE OF 25,000 KW. RESERVE. THE PRESENT MAIN EQUIPMENT IS EIGHT 1000-HP. WATER-TUBE BOILERS AND THREE, TEN-STAGE 12,500-KW. TURBINE GENERATORS. THE TURBINE ROOM IS 131 FEET WIDE AND 195 FEET LONG; THE BOILER ROOM IS 68 FEET WIDE AND 285 FEET LONG



POWER

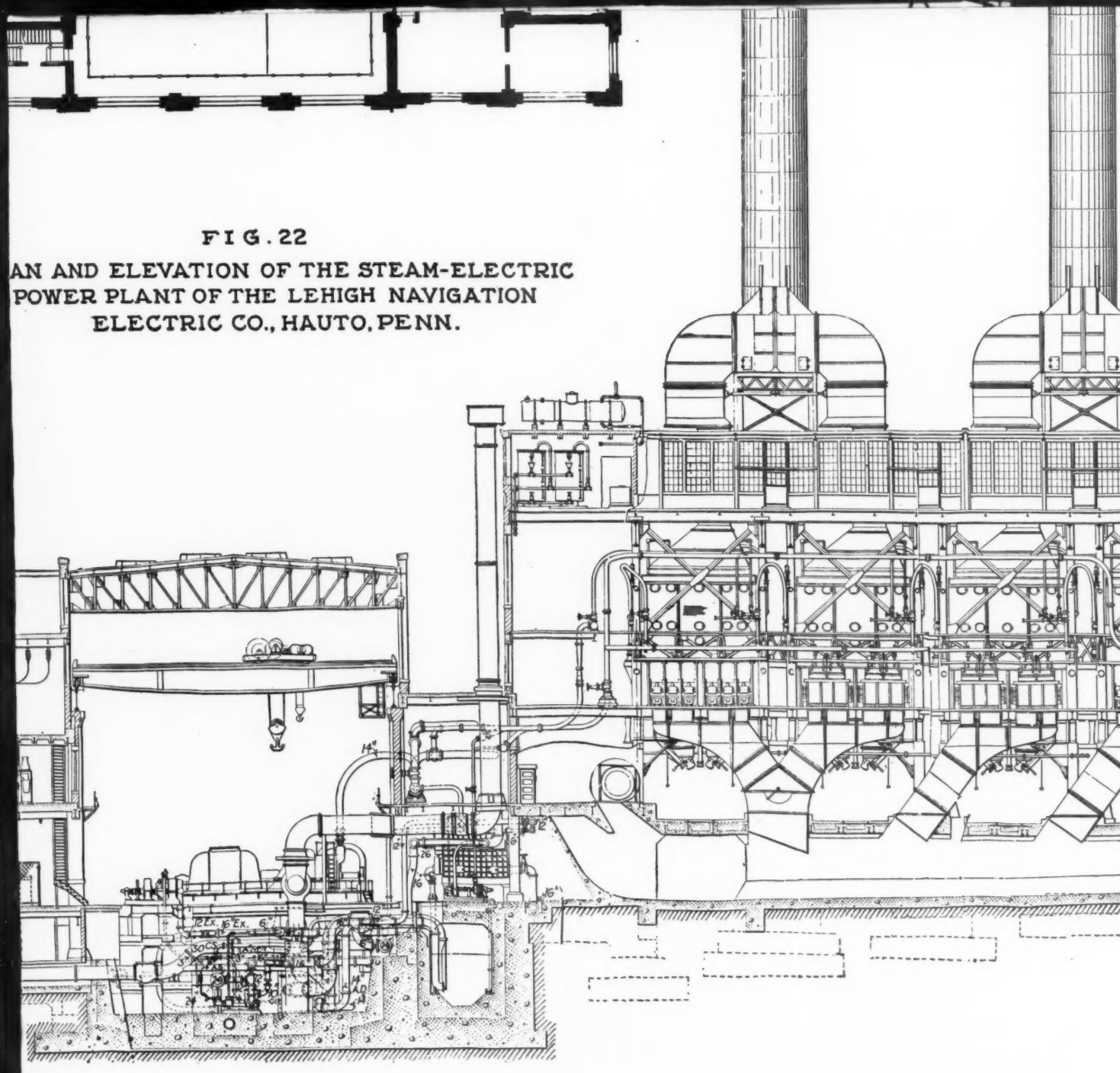
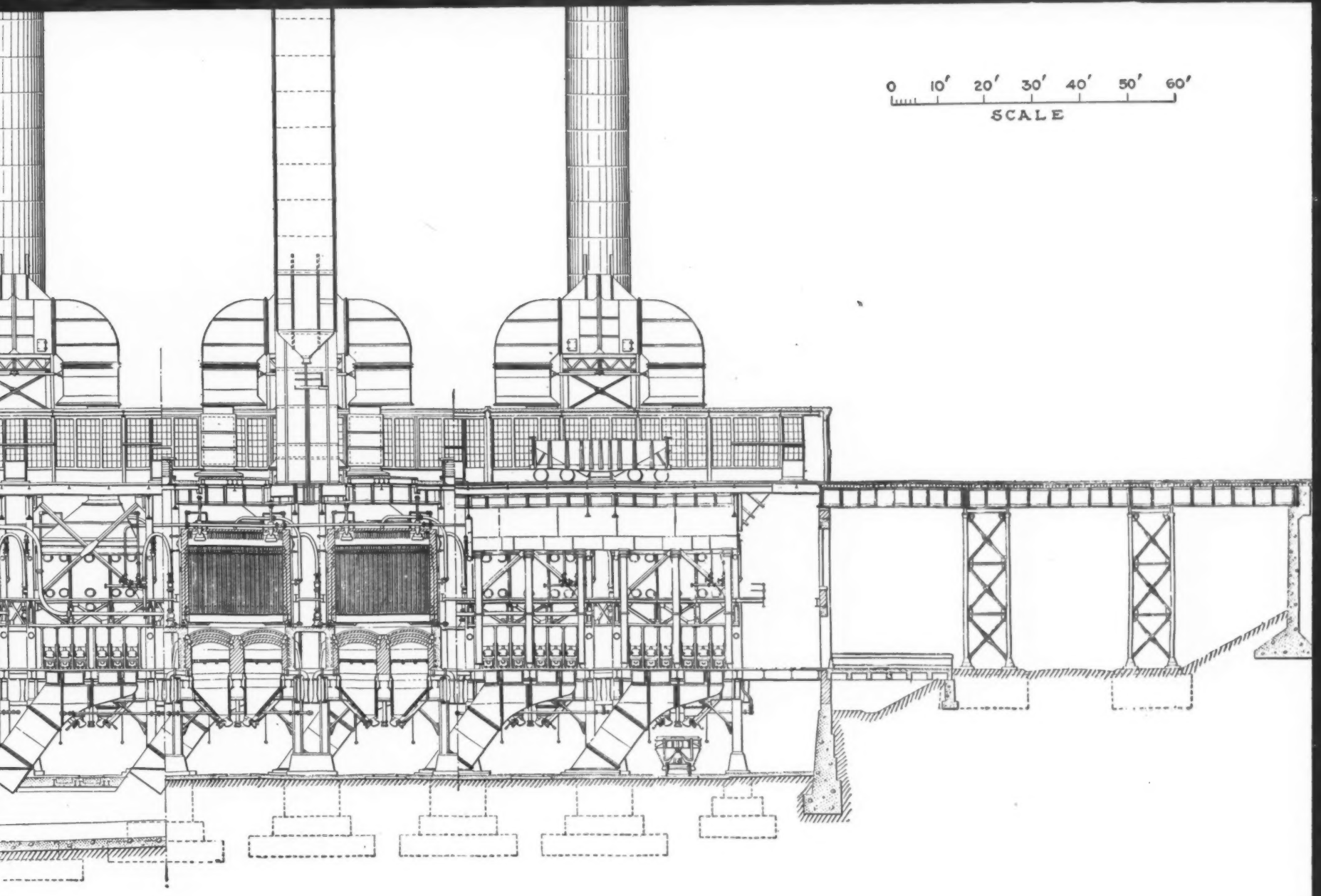
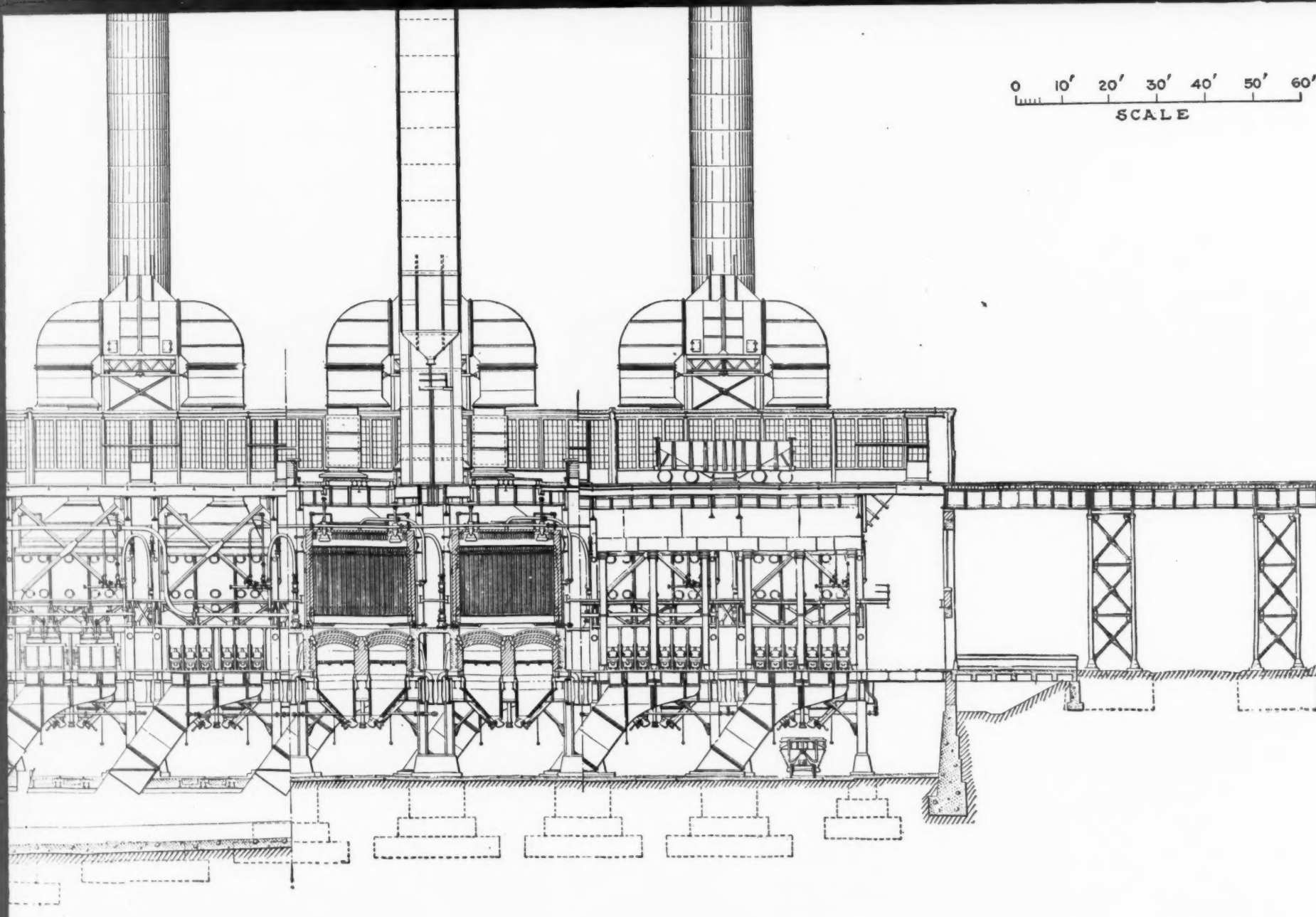


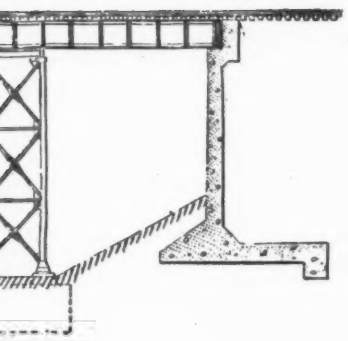
FIG. 22

AN AND ELEVATION OF THE STEAM-ELECTRIC POWER PLANT OF THE LEHIGH NAVIGATION ELECTRIC CO., HAUTO, PENN.


0 10' 20' 30' 40' 50' 60'
SCALE


0 10' 20' 30' 40' 50' 60'
SCALE

60'



All steam for the auxiliaries in the basement is taken from the headers in the header room through two 8-in. mains to an auxiliary header in the pump room. Three 4-in. branch pipes run from this header to the pumps and to the turbine driving the condenser pumps. The 4-in. lines for the condenser-pump turbines are taken from a steam header in the basement, as are also the pipes connecting with the exciter turbines.

All exhaust steam from the auxiliary unit goes to either of two 18-in. main exhaust-steam lines which terminate in an 18-in. header above the boiler-feed pumps and connect with each heater through a tee connection. This header is piped to two 18-in. atmospheric exhaust lines, running vertically through the roof of the header room, the top being 75 ft. above the heaters. The header is fitted with valves so that each heater can use exhaust steam from any battery of pumps or any auxiliary turbine.

The loop plan is carried out on all pipe lines, this provision making it almost impossible for the entire plant to be disabled through an accident to the boiler pipe lines or headers. The high-pressure exhaust steam and hot-water pipes are covered with 85 per cent. magnesia, as are also the feed-water heaters; there are over 50,000 lineal and square feet of this covering in the plant.

The low-pressure pipes of from ½ to 6 in. in diameter are insulated with standard 85 per cent. magnesia covering; the saturated-steam lines of from 2 to 6 in. are protected with two layers of covering; the hot-water lines, 1½ to 6 in., are covered with 1½-in. thick magnesia; the superheated-steam lines, from 7 to 16 in., with 3-in. thick 85 per cent. magnesia and the feed-water heaters, boiler drums, etc., have the same thickness. All flanges and fittings have the same covering as the superheated-steam lines.

All high-pressure steam pipes are drained of condensation by the Holly drip and the open-blow systems; the latter discharges into the exhaust main to the feed-water heaters. All low-pressure lines drain into two sump pits, each automatically emptied by a motor-driven pump, the water being discharged into three tanks on the roof of the boiler house and used as desired for sprinkling the ashes.

Piping Identification

The color idea carried out on the pipe lines is to paint the flanges the color designating the service for which the line is used. Black is for cold water; bright red, high-pressure steam; dark red, low-pressure steam; yellow, oil; blue, feed water.

The oiling system is piped to a special oil filter in a room on a level with the car track which enters one end of the turbine room. Filtered oil is pumped to elevated oil tanks in a tank room at one end of the boiler room above the boilers. These tanks are cross-connected and serve as reservoirs for the oil used by the plant; the supply pipes run to the various bearings of the units. The oil is handled from the filter to the storage tanks by a 7 and 5 by 12-in. vertical, duplex steam pump.

A traveling crane spans the turbine room 63 ft. 2 in. center to center. The auxiliary hoist has 10 tons capacity, the main hoist 90 tons and the bridge 110 tons; the lift is 147 ft. 11 in. The main hoist motor is of 35 hp., the auxiliary 33, the bridge travel 33, and the trolley transmission 11 hp. capacity.

The fourth and last article of the Hauto plant will deal with the electrical equipment.

Connections of Compound and Interpole Motors

By F. A. Annett

The connections of a compound motor are not necessarily more complicated than those of a series or shunt machine when the compound machine is viewed as only a series motor with a shunt field winding on it.

To illustrate, consider Figs. 1, 2 and 3, showing respectively the connections of series-, shunt- and compound-wound machines. By tracing out the armature circuit in Fig. 3, which is from the positive side of the switch to the L-connection on the starting box, from the A-connection on the starting box to the A-connection on the motor, and through the armature and field to the negative side of the line as indicated; this is found to be identical with the series-motor circuit, as shown in Fig. 1. Hence, when making the connections of a compound motor, if the armature and series field are connected as a series machine, they will always be right, and all that will be left to consider is the shunt field. If the latter circuit is traced out in Fig. 3, it will be seen to run from the F-connection on the starting box to the shunt field (Sh. F_1) connection on the motor and from the Sh.F-connection to the line; this being identical with the field connection in Fig. 2, which bears out the statement that the compound machine is nothing more nor less than a series machine with a shunt field on it.

Care should be taken to determine which is the series and which is the shunt field on the machine before making the connections, for if the series field is connected in shunt the no-voltage coil will be burned off the starting box or the fuse blown. The series field is always shown on the diagram in heavy lines, while the shunt field is shown in light lines. On all compound motors, except small sizes, the series-field leads are much larger than those of the shunt field. In the small machines, when the shunt- and series-field leads are the same size, the two fields may be determined by testing with a lamp. The lamp will burn brightly through the series field and dimly through the shunt field. After the motor has been connected it is advisable to make a test to determine if the connections have been made correctly. This can be done in the following way:

Disconnect the armature connection on the starting box, likewise the armature connection on the motor, as shown in Fig. 4; then close the switch and move the starting arm to the first contact, as shown by the dotted line. If the connections have been made properly, and the switch is opened or the starting-box arm allowed to drop back to the off position, a severe spark will occur. If there are doubts as to which field has been connected in

shunt, do not move the starting-box arm upon the first contact, but connect a lamp as shown in Fig. 5. If the shunt field is connected correctly the lamp will burn dimly and a severe spark will occur when the circuit is open If the series field has been connected in place of the Fig. 6, then start the motor as a series machine and note the direction of rotation. *Do not cut out the starting resistance as the motor will reach a dangerous speed.* Stop the machine and connect the shunt field, then short-circuit the series-field connections as shown by the dotted

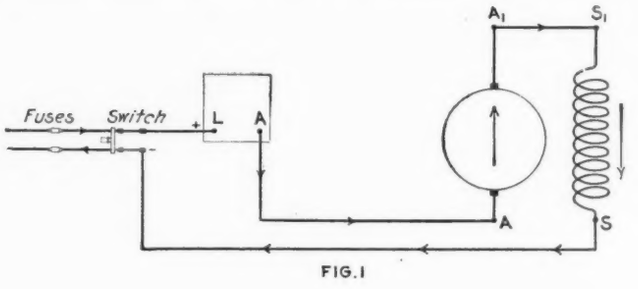


FIG. 1

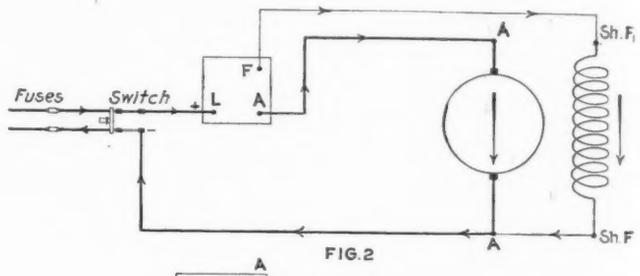


FIG. 2

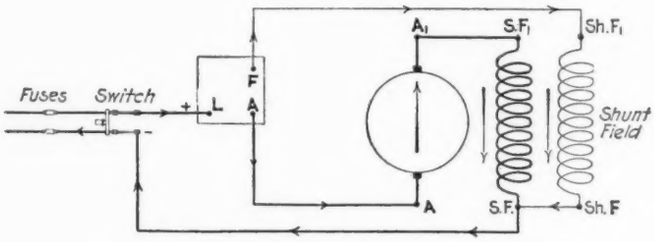


FIG. 3

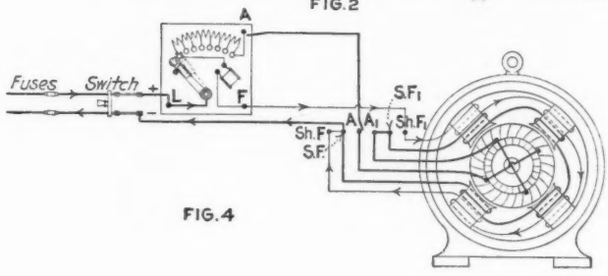


FIG. 4

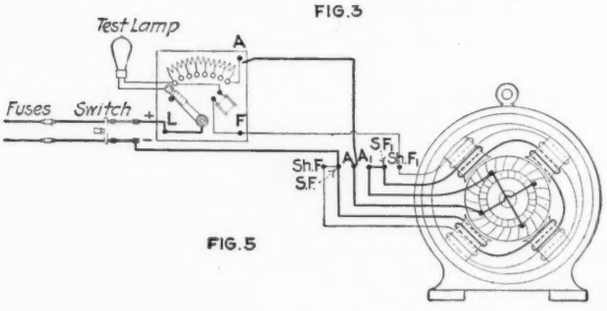


FIG. 5

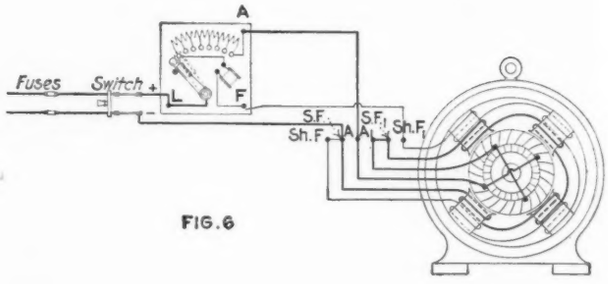


FIG. 6

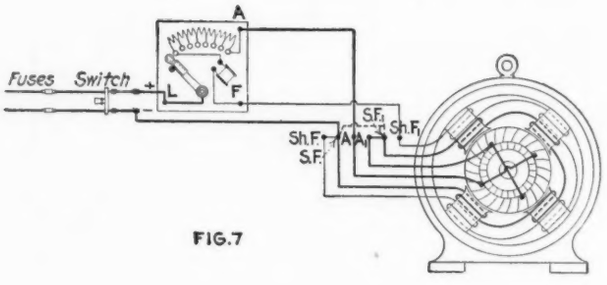


FIG. 7

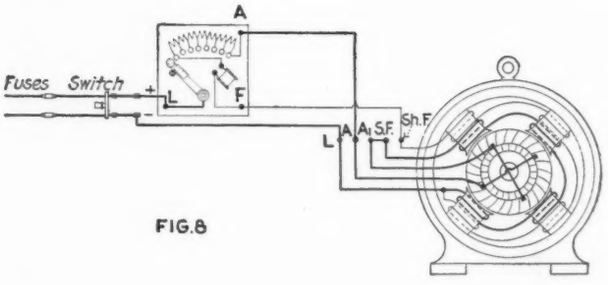


FIG. 8

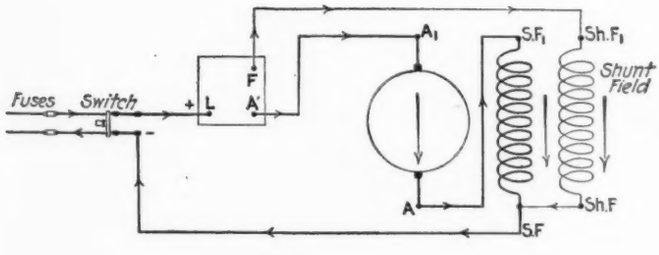


FIG. 9

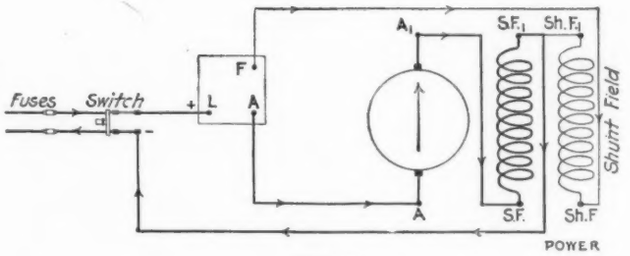


FIG. 10

shunt the lamp will burn to full brilliancy and no spark will occur when the circuit is broken.

After the connections have been tested and found to be correct, the next thing to test for is the polarity of the shunt- and series-field coils, which should be the same. To do this, disconnect one side of the shunt field as in line in Fig. 7 and start the motor again. If the armature turns in the same direction as before, the series and shunt field have the same polarity. If the direction of rotation is opposite to that produced by the series field the series- and shunt-field coils are of opposite polarity. To remedy this, if the shunt field gives the desired direc-

tion of rotation, interchange the series-field leads. If the series field gives the desired direction of rotation, interchange the shunt-field connections. The polarity of the series- and shunt-field coils may also be tested by taking the speed of the motor, first as a compound machine, then short-circuit the series field as indicated in Fig. 7 and again take the speed. If the speed increases with the series field short-circuited, the polarity is correct. If the speed decreases, the polarity is wrong.

Series- and shunt-field coils of opposite polarity in a compound motor may produce several effects, depending upon the strength of the series field. It may cause a slight increase only in speed from no load to full load, but in most cases it will cause one of the following effects:

(1) The motor may start and operate satisfactorily under no load. When the load is put on it may suddenly increase in speed and spark badly at the brushes, causing the fuses to blow or throw the circuit-breaker.

(2) The motor may decrease in speed to the point where the fuses will blow, and if not properly fused may stop, reverse and run in the opposite direction; this will be accompanied by severe sparking at the brushes.

(3) The motor may start in one direction and when the starting resistance is partly cut out it will stop, reverse and run in the opposite direction.

(4) The motor may fail to start, the armature usually making slight efforts to turn in one direction and then in the other.

If the series-field coils are of the right proportions, a constant speed will be had from no load to full load. This condition is seldom, if ever, found except in motors designed to accomplish this purpose.

Several of the electrical manufacturers connect one terminal of the series- and shunt-field coils together inside the machine, after first determining the correct polarity of the field coils. This leaves but five terminals coming to the outside, as in Fig. 8, which eliminates the necessity of finding the correct polarity when the machine is connected up.

To reverse the direction of rotation of a compound motor, it is usually best to interchange the armature connections, as in Fig. 9. By comparison with Fig. 3 it will be seen that the direction of the armature current in Fig. 9 is opposite that in Fig. 3, which will cause the armature to turn in the opposite direction.

The direction of rotation may also be reversed by interchanging the field connections where both of the series and shunt terminals have been brought to the outside. Care must be taken to interchange both the series- and shunt-field connections as indicated in Fig. 10. If compared with Fig. 3, it will be seen that the current is in the same direction in both cases in the armatures, but opposite in the field windings.

What has been said in reference to the simple series, shunt and compound machines also holds true for the same class of machines with interpoles. Fig. 11 shows the connections of a shunt-interpole machine The external connections are the same as those in Fig. 2, and the only change in the internal connections is the interpole winding connected in series with the armature. One side of the interpole winding is always connected to one side of the armature, with one armature and one interpole connection brought to the outside terminals.

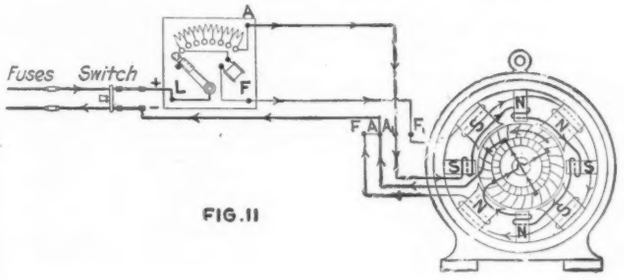


FIG. 11

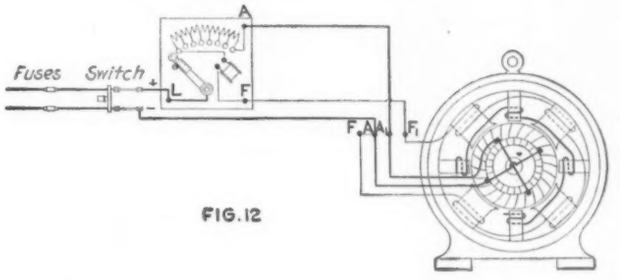


FIG. 12

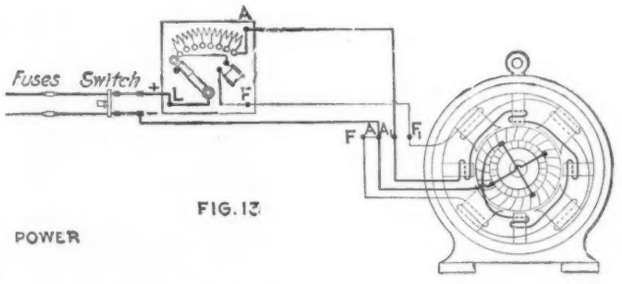


FIG. 13

POWER

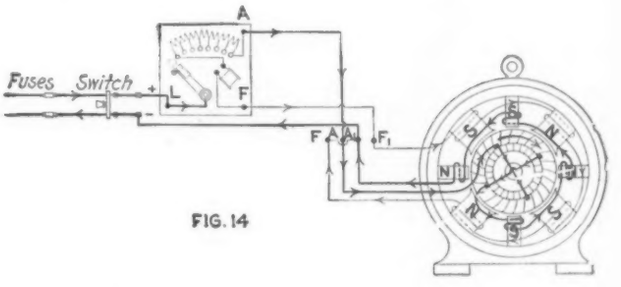


FIG. 14

Care should be taken to have each interpole of the proper polarity, which should be the same as the following main pole. This condition is shown in Fig. 11, for the direction of rotation indicated. Usually, when the machine leaves the factory the interpole winding is connected for the correct polarity; therefore on most new machines this problem is already solved, and the connections can be made to the starter and switch the same as for a motor without interpoles.

After a machine has been taken apart for repairs, unless the connections have been carefully marked, it will be necessary to test the interpoles for polarity when assembling. A practical way to do this is, first, to connect the machine in shunt, as in Fig. 12, and see that it is operating properly, with all the starting resistance cut out. The motor may then be shut down and one side of the shunt field opened. After carefully marking the position of the brushes on the bearing bracket and rocker arm, shift them three or four segments around the commutator; then connect the interpole winding in series with the armature and start the motor again, this time being careful *not to cut out the starting resistance* as the

motor will race and may reach a dangerous speed. Note the direction of rotation, and if the armature turns in the same direction as that in which the brushes are shifted, the interpole polarity is correct. If it turns in the opposite direction the polarity is wrong. To remedy this, interchange the armature or interpole connections as shown in Fig. 13 and test the machine again. This time, if everything has been done correctly, the rotation should be the same as the direction in which the brushes were shifted. After the desired condition has been obtained, open the switch and shift the brushes back to their positions and connect up the shunt field to give the motor the desired direction of rotation.

If the interpole is of the wrong polarity, the brushes will spark and burn and the machine will have a marked decrease in speed with an increase in load.

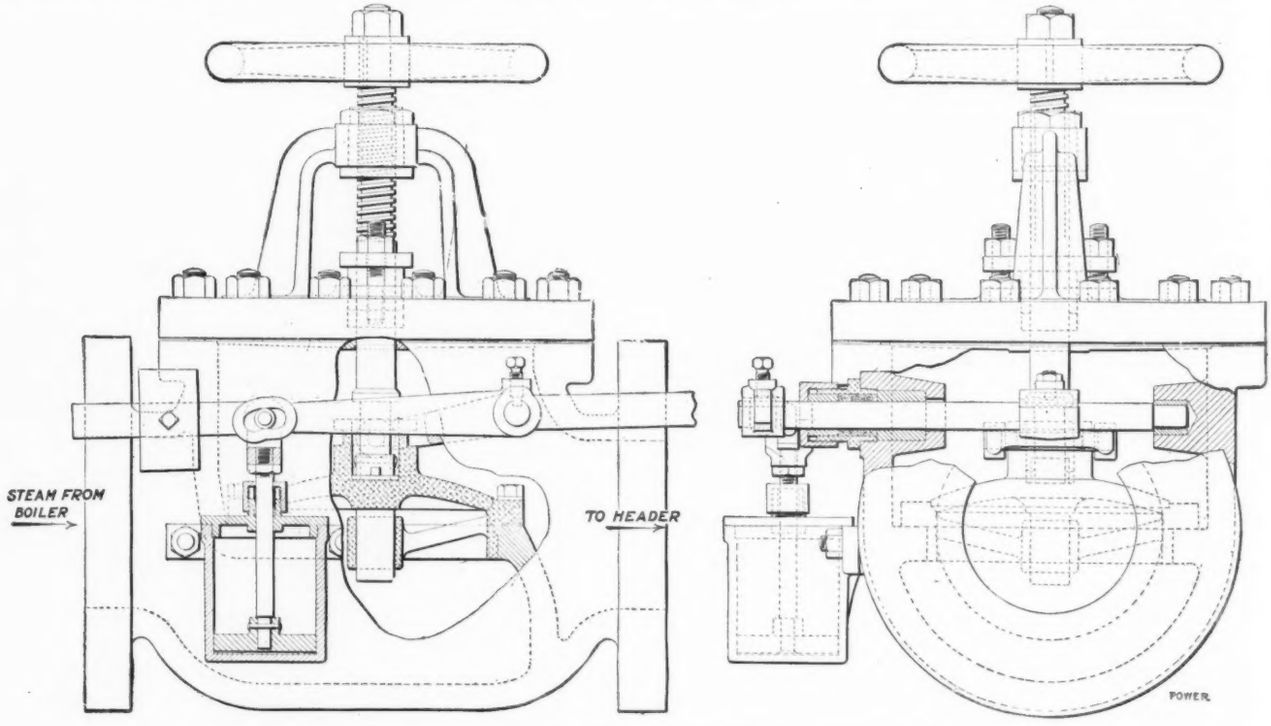
Interchanging the shunt-field connections is usually the easiest way to reverse an interpole shunt motor, although the direction of rotation can be reversed by changing the terminals of the armature circuit, which must include the interpole winding as in Fig. 14. By comparing the direction of the currents in the armature and interpoles in Figs. 14 and 11, they will be found to be opposite, as indicated by the arrowheads.

Automatic Nonreturn Stop Valve

The illustration shows a 5-in. nonreturn valve which does away with the internal dashpot and piston, the rod of which connects with an outside lever, pivoted as shown. The lever indicates the amount of the valve opening and is a check on the fireman when several boilers are used, showing whether a boiler is producing its proper amount of steam.

The valve, manufactured by the Strong, Carlisle & Hammond Co., 326 Frankfort Ave., N. W., Cleveland, Ohio, is made extra heavy, with an area of 10 per cent over the pipe size. This excess area eliminates wire drawing or cutting down the volume of steam passing through the valve. All joints are ground, and metallic packing is used in the bronze bearing of the horizontal rod operated by the valve disk. The seat and disk are made of bronze or superheated metal, according to the conditions under which the valve is to be used. The valve stem can be packed under pressure, as when the valve is wide open the bearing ring on the valve stem comes against a ground seat.

The valve disk is in constant motion when the boiler is producing steam, which should avoid any danger of sticking. If the valve is inoperative at any time, it would be shown by the movement of the outside lever. If such a condition does occur, the valve can be put in operation by hand.



Semi-Sectional View of the Strong Automatic, Nonreturn Stop Valve

Oil-Engine-Driven Air Compressor

The increased use of low-grade oil fuel for power purposes has led to the design by the Ingersoll-Rand Co. of the oil-engine-driven air compressor herewith shown. This is of the direct-connected, straight-line type with an inclosed frame employing a splash system of lubrication.

The feature of greatest interest in this machine is the design of the driving end, which consists of a single oil-engine cylinder set behind the air cylinder and directly connected by means of an extended piston rod to the air piston. It follows in general design the hot-bulb type, is single acting and works on the two-stroke cycle. A torch is fitted for heating the ignition bulb preliminary to starting; after the compressor is under way this torch is dispensed with.

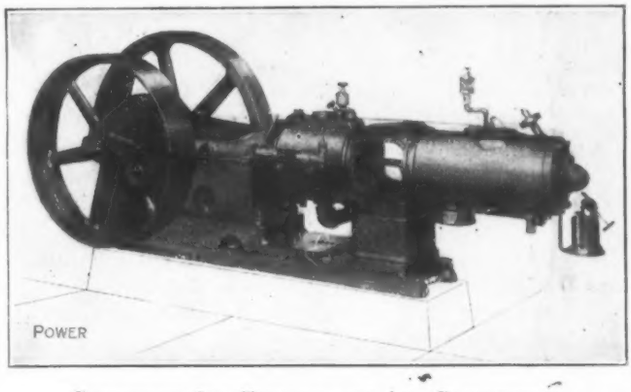
Fuel is automatically injected into the combustion chamber by a small pump on the side of the frame, op-

erated by the main shaft. It enters in the form of a finely atomized spray and is immediately ignited by the hot bulb. The stroke of the fuel pump is regulated by a centrifugal governor in the flywheel, thus regulating the amount of fuel injected into the cylinder in proportion to the load. This is supplemented by a regulating device on the intake to the air cylinder.

The operation of this machine is not accompanied by the losses common to the average two-stroke-cycle gasoline engine, in which part of the incoming charge follows the exhaust gases through the outlet ports and is wasted. This is because the fuel is not vaporized by an outside agency and introduced with the air used for scavenging, but is injected directly into the cylinder at the end of the compression stroke. This means that pure air is used during the scavenging period of the stroke; consequently the inlet and outlet ports can be so arranged that more thorough scavenging is afforded without any loss of fuel.

Like a number of the engines of this type, a small quantity of water from the cylinder jacket is injected into the combustion space. This water performs the function of regulating the temperature in the cylinder, thereby preventing preignition. It also reduces the maximum pressure in the cylinder and tends toward making a smooth-running engine. The amount of water injected is regulated according to the load on the compressor.

The combined machine is at present made in only one size with an actual capacity when running at 325 r.p.m. of 66 cu.ft. of free air at 100 lb. pressure and 73 cu.ft.



COMBINED OIL ENGINE AND AIR COMPRESSOR

at 80 lb. pressure. The fuel consumption at this speed, and under average operating conditions, is about 2.2 gal. of kerosene per hour. It is adapted to run on either kerosene, fuel oil or distillate. Its weight complete is 3000 lb. and the floor space taken up is 8 ft. 10 in. by 2 ft. 5 in.

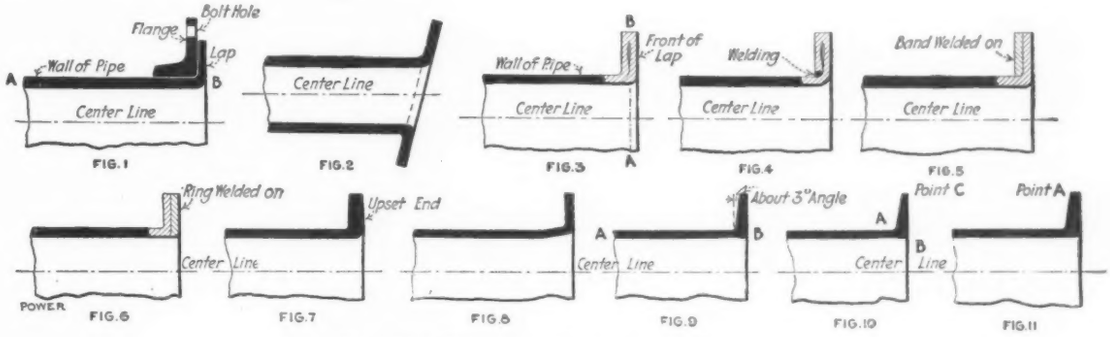
Van-Stone Joints

Within the past few years there have been many changes in the design of the joints for piping, and so many so called improvements have been made on the van-stone type that the consulting engineer is confronted with a problem when determining the type of van-stone joint that is best for his requirements.

An analysis of the strains on a van-stone joint under service will show that the stress, due to pressure in the line, will be a circumferential tension, the internal pressure tends to draw the lap back through the flange, which results in a shearing stress along the line *AB*, Fig. 1. Due to structural strains, the stress will be bending, or a tendency to draw the lap through the flange, which would result in the lap being bent at an angle to the axis of the pipe, Fig. 2.

The van-stone joint, one of the strongest possible, is of advantage in the field, as all trouble in aligning bolt holes is overcome, and piping with such joints can be placed in far less time than any other style of flanged joint; if the joint is made properly at the shop the piping system will give satisfaction in service.

The following description of the various styles of van-stone joints may be of interest to engineers in determining the relative merits of each. In making the joint shown in Fig. 3, the end of the pipe is heated, spun out and pressed back upon itself, giving, after machining, a lap thicker than the wall of the pipe. A little consideration will show that the distribution of metal in the lap cannot be equal as the back part of the lap will stretch more than the front; also, it is practically impossible to get a perfect weld along the line *AB*. In some instances, if this type of joint is cut in section, a small pocket will be found traveling around the outer portion of the lap. In time, water of condensation, when the line is cold,



VARIOUS TYPES OF VAN-STONE JOINTS

will find its way into this pocket. Unless the two laps are absolutely welded the shearing resistance cannot be any stronger than that of the ordinary van-stone joint.

Another type of joint is shown in Fig. 4. The end of the pipe is heated and spun over, and while still hot the lap is forced back upon itself. It is again heated and spun over, and the corner at the back of the lap is welded up. This lap is also thicker than the wall of the pipe when machined. It has practically the same faults as the one shown in Fig. 3, except that water cannot find its way into the pocket formed by faulty welding.

In the joint shown in Fig. 5, a band is welded on to the end of the pipe before van stoning. A ring is welded on to the lap, Fig. 6, after the lap is made. As both joints, Figs. 5 and 6, are makeshifts, the welding for mechanical reasons is rarely if ever perfect, and in the case of Fig. 6, steam will frequently leak through the supposed weld to the periphery of the lap.

The end of the pipe in the joint shown in Fig. 7 is heated and upset, then reheated and spun out in the usual manner, giving a lap thicker, after machining, than the wall of the pipe. Sections cut from this style of joint and given a pulling test have shown that the tensile strength has gone from the average 55,000, to as low as 20,000, and the elastic limit to 10,000 lb. per sq.in. This is, no doubt, due to fiber distortion and crystallization.

The joint shown in Fig. 8 is practically the ordinary van-stone joint, except that the pipe just back of the corner of the lap is slightly funneled out; the flange is also funneled out to meet the pipe. The lap is slightly thinner than the wall of the pipe after machining.

The flange shown in Fig. 9 is as it was originally designed. The pipe is heated and spun out; the lap is slightly thinner than the wall of the pipe after machining; the back of the lap is about 3 deg. from the vertical in order to leave the lap at the point of shear—that is, along AB—equal in thickness to the wall of the pipe.

The joint shown in Fig. 10 is slightly upset during the process of spinning out to obtain the square corner, and the thickness along the line AB is about one and a half times the wall of the pipe. The thickness at the point C is less than the wall of the pipe. Consideration will show that this type of joint is the strongest of all, and gives the greater bearing area for the gasket.

The joint, Fig. 11, is practically the same as Fig. 10, except that the end of the pipe is upset a trifle more, giving a full thickness at the point A.

Tests have been made on the ordinary van-stone joint, Fig. 9, which show that it will hold considerably more pressure than the bolts, and with specially designed flanges and bolts it has been proved that the pipe will burst before the lap will be injured. Structural tests for tension compression and bending show that stresses well up to the elastic limit of the pipe must be imposed before any serious damage is done to the lap.

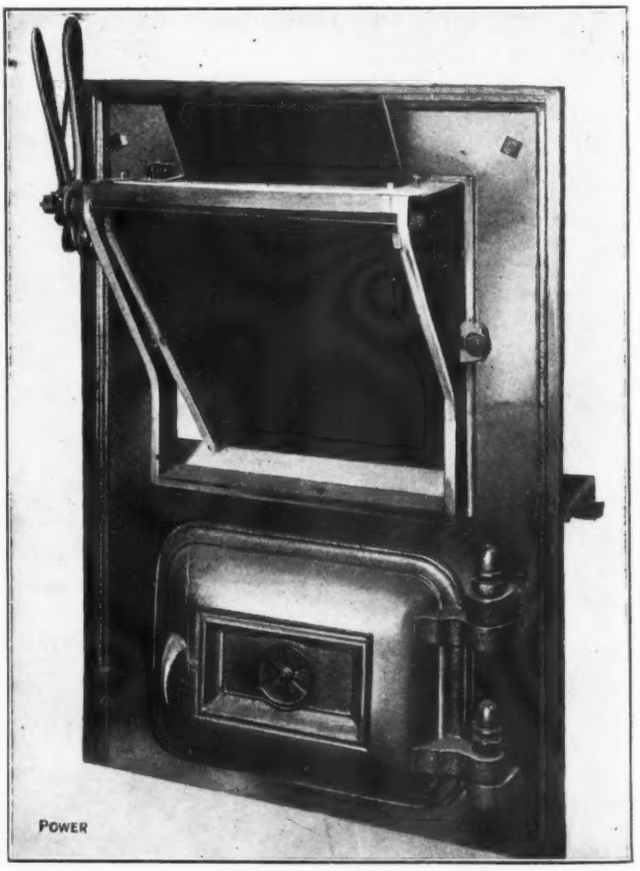
Van-stone joints cannot be made with wrought-iron pipe, owing to the different fiber structure, and steel pipe must be used. The necessary points for a good van-stone joint are that the flange should fit the pipe in the hub snugly, to give support to the pipe to bending stress. For all steam pressures above 150 lb., high-hub flanges should be used. These flanges should be made of rolled steel, forged steel or cast steel on all pipe for pressures above 150 lb. The face of the lap should be machined to give good gasket holding; all scale should be removed from the back of the lap and the flange should have a full bearing against the lap.

The operation of van-stoning should be done with the pipe at a bright red heat, and the machine used to turn the lap over should be designed to gradually spin the end out and then force the lap back; by this method a better distribution of the metal in the lap is obtained. Many machines simply funnel the end of the pipe out by means of a taper roll, but this method does not allow a proper stretching of the pipe to accommodate itself to the increased diameter of the lap. Facing the lap while hot should not be resorted to, as it frequently draws during cooling, and any irregularity would not be noticed until the pipe is put under pressure. Facing by means of revolving cutters, set radially, does not give a good face, and chatter marks frequently result from this method.

McGinniss Safety Fire-Door

For some time the R. M. Eddy Foundry Co., Chicago, Ill., has been making a safety fire-door which opens inward and tends to prevent injury to the firemen in the case of a gas explosion or the rupture of a boiler tube. Formerly this door was mounted inside of the furnace, but for convenience of erection and to add to the life of the door, it is now applied outside and attached to the boiler front by a lug and bolt on the sides. It is thus easy to fit the door to any boiler, new or old.

In the illustration the door is shown mounted on a boiler front made up in the shop. The frame is made of cast iron and the fire-door plate of sheet steel. Guides



McGinniss Safety Fire-Door

bolted to the frame prevent the door from opening outward; the angle at which they are set may be varied so as to close completely the furnace opening. The door is opened by the ratchet handle shown at the left, and will stay in the position at which it is set. A roller secured to the top of the fire-door plate raises the air flap on top of the casting. By means of a dog with several notches, and a pin attached to the flap, the latter is automatically checked and held open until released by hand. The flap admits air over the fire to mix with the volatile and reduce the smoke immediately after firing. If the coal is highly volatile, the fire-door may be set open at any point to admit more air.

The door thus combines the features of safety and smokeless operation. It is simple, and if it ever becomes necessary, the sheet-steel door plate may be replaced by taking out a couple of screws at the top of the casting. Patents for the safety door have been applied for.

Steamfitters' Drafting Square

Did you ever notice the vertical and horizontal length of a pipe line out of level and out of plumb? This is usually caused by one of the pipes being cut short and then sprung to get it in place.

A device has been patented which, if properly used, will eliminate such faulty work. It consists of a graduated folding square, made with two blades. One of the blades is graduated on both sides and pivoted at the end

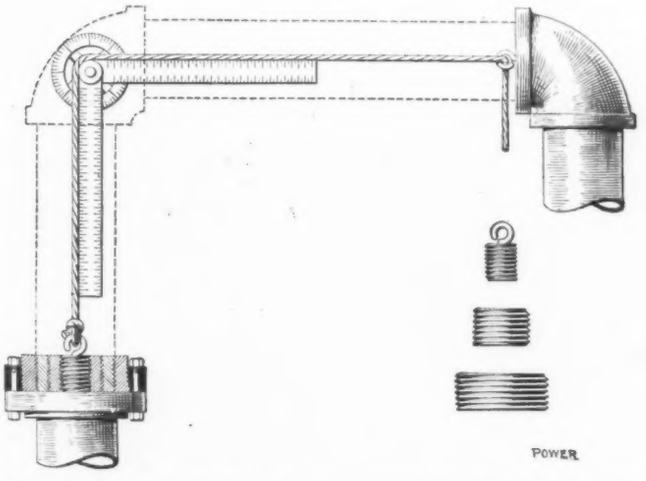


FIG. 1. SQUARE USED FOR DETERMINING PIPE LENGTHS OUTSIDE OF ELBOW FITTINGS

between the center of a protractor head and the other blade which is graduated on one side only. The protractor is graduated in degrees. On the four edges of the square are marked the standard sizes of 45- and 90-deg. and of flanged and screwed elbows.

Fig. 1 illustrates how the square is used. If a pipe line is to contain a 90-deg. elbow, plugs the size of the pipe and made for the purpose are screwed into a coupling or flange on the ends of the pipes. On the center of this plug is a hook to which a cord is attached. When properly adjusted and the square is in place, as shown, the cord will be plumb with the center of the vertical pipe and in line with the center of the horizontal pipe. After placing the square it is a simple matter to measure from the end of the pipe line to the marked size of the elbow on the square and, allowing for threads, the proper length of pipe to use is determined.

If it is desired to space a certain number of holes in a given circle, say, in the flange of a fitting, the same device can be used. The inner blade has a slot cut for a trammel to slide in, and is held in place by a nut. The blade is pivoted at the center of the protractor, by a pivot

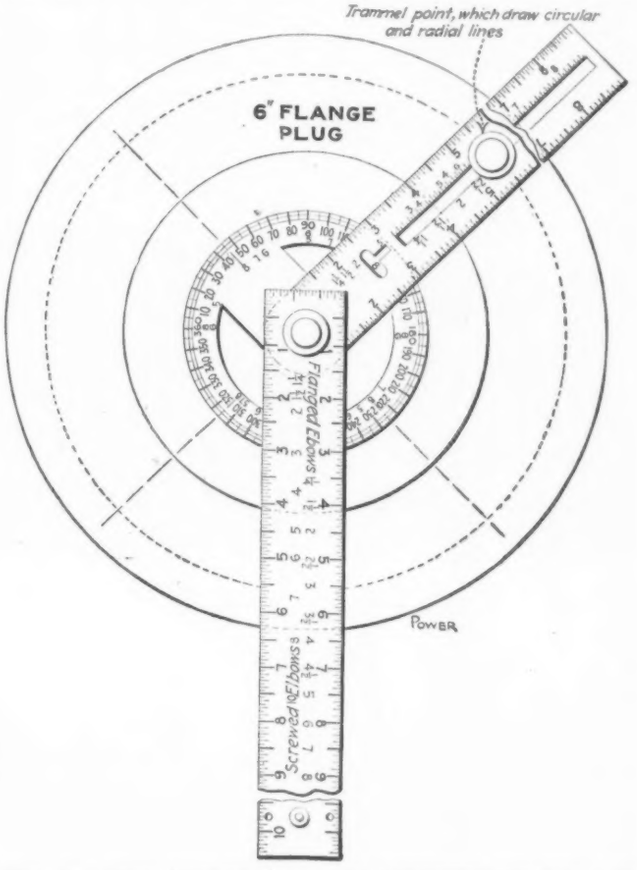


FIG. 2. THE DEVICE USED FOR SCRIBING CIRCLES AND SPACING BOLT HOLES

bolt through the center of which is a thumb-screw having a center pointer at the end. When in use, the square is screwed in the flange, placing the pivoting bolt through the center. Then the trammel is set for the given circle, and by revolving the inner blade the diameter is ascribed and then graduated into spaces of 4, 5, 6, 7, 8, etc. If eight holes are desired in the flange, the blade is turned to the point marked 8 on the protractor circle. The trammel is then slid across the circle mark. The design of the device is shown in detail in Fig. 2. It is patented by Thomas G. Tedesco, Peckville, Penn.

Cylinder Head Knocked Off—About 3 p.m., Wednesday, June 10, the piston rod of an 11x12-in. Phœnix engine in the Hallenbeck Building, 505 Pearl St., New York City, broke next to the crosshead, allowing the piston to push off the cylinder head as the crosshead returned on the next stroke. The cylinder head faced the wall, and, as no one was injured, the damage is confined to the engine.

Remarkably Low Fuel Consumption—The recently issued report of A. H. Keene, chief engineer of the Pawtucket Water-Works, credits No. 4 Pumping Station with a delivered horsepower on 1.31 lb. of coal per hour, counting all the coal weighed into the station. The coal per delivered horsepower-hour, based on the pumping coal, was 1.14.

Large Atmospheric Cooling Tower

One of the largest atmospheric cooling towers in this country has recently been installed at the main power house of the South West Missouri R.R. Co., Webb City, Mo. The tower was built by the Mitchell-Tappen Co., New York City, and is of standard steel construction. It is 123 ft. long, 19 ft. wide and 30 ft. high to the walkway, and has a capacity of 2000 gal. per min. cooled from 120 to 80 deg. F. under the mean July atmospheric conditions of the vicinity which are dry bulb, 75 deg. F.; wet bulb, 67.5 deg. F., and relative humidity, 68 per cent.

These results are somewhat better than that given by the standard formula of the guarantee under which these towers are sold, which is:

$$T_1 = \frac{t + 2t_1 + T}{4}$$

where

t = Temperature, dry bulb or air;
t_1 = Temperature, wet bulb;
T = Temperature, entering water;
T_1 = Temperature, leaving water.

A side view of the tower is shown in Fig. 1 and the top

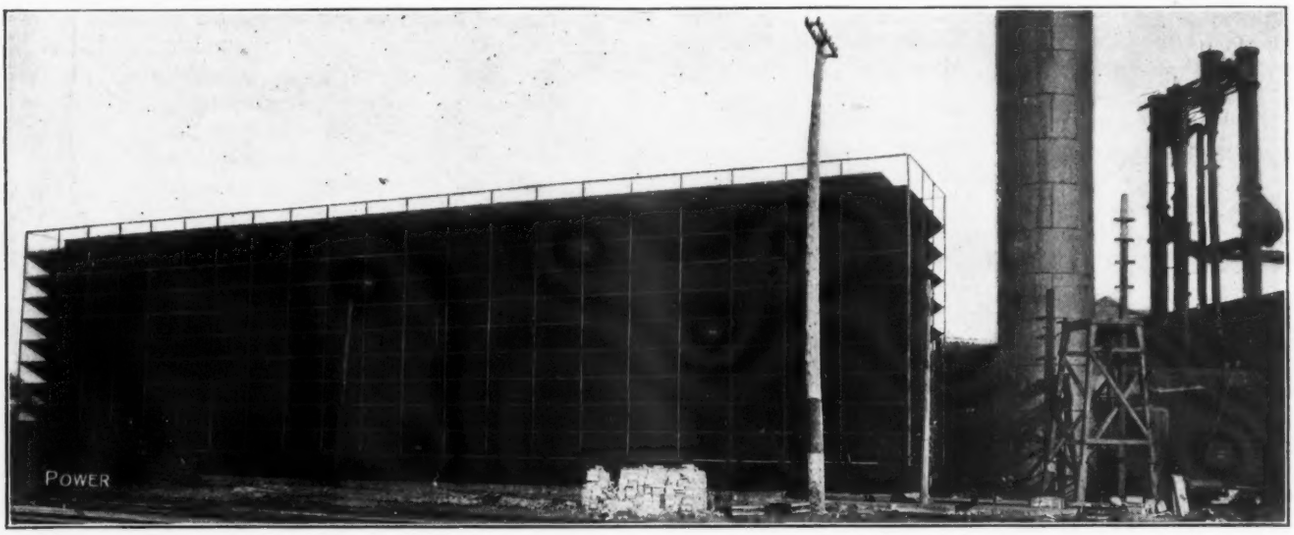


FIG. 1. SIDE VIEW OF LARGE ATMOSPHERIC COOLING TOWER

FIG. 2. VIEW OF TOP OF TOWER, SHOWING LAUNDERS AND TROUGHS

in Fig. 2. The entering water is pumped direct to the top and is carried by branches to the transverse receiving troughs (launders), from which it flows to the distributers. The distributers overflow, the water running over the side and following the surface to the points from which it drops into small semi-cylindrical troughs which make up the distributing deck. These cedar troughs also overflow, dropping the water in a shower on the decks below. The decks or platforms are long, narrow trans-

verse cedar strips or drip-bars, each of which divides the water it receives into two parallel rows of drops, thus producing maximum subdivision. Spaces between the drip-bars allow the water to descend from deck to deck, the alignment of the bars and the width of space being secured by a system of interlocking splines or separators, which unite the separate bars, thus forming a solid and continuous deck capable of resisting warping and twisting tendencies. There are 10 decks, counting the top dis-

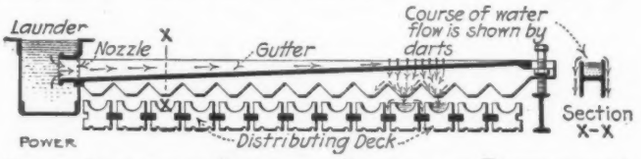


FIG. 3. SECTION OF LAUNDER, GUTTER AND DISTRIBUTING DECK

tributing deck. The spray louvers are of Louisiana cypress tongue-and-groove boards set up tight to a smooth, flush surface.

The steel skeleton, braced against wind stresses, and accessible for painting and inspection, consists essentially of a series of vertical lattice girders and horizontal members to which are bolted the decks and louvers.

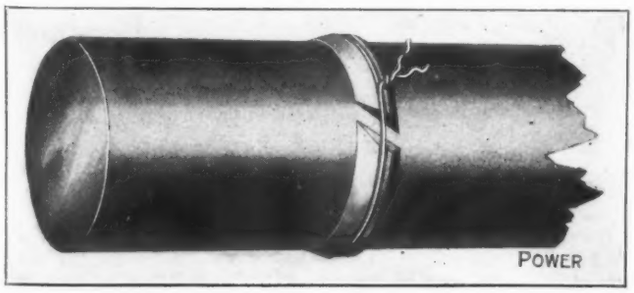
The tower structure is of ample strength, with minimum weight. The foundation is of concrete, combining the anchorage and receiving basin.

Fig. 3 is a sectional elevation of the launders, distributer and distributing deck. The distributer, or gutter, has an inclined bottom, producing a gradually decreasing section as the water travels out, the effect of which is to produce a uniform overflow at all velocities; in addition, there are no perforations, slots or notches to clog and destroy the uniform distribution upon which efficiency largely depends.

The tower has a capacity of about 2400 hp. at reasonable steam consumption and 26 in. vacuum. At present, it is serving approximately 1800 hp. in connection with two barometric condensers.

"Cassco" Packing

"Cassco" is the trade name of a metallic packing made in bar or ring form which possesses the characteristic of expanding when cooling and contracting when heating. This tends to prevent steam or water blowing out when starting a "cold" engine or pump, and as it contracts slightly as the metal expands, due to the heat of the steam, the friction does not increase when the engine is under way. Graphite is mixed thoroughly with the substance of the packing, so that it is self-lubricating, and as it is semi-plastic when warm, there is no tendency to score the rod.

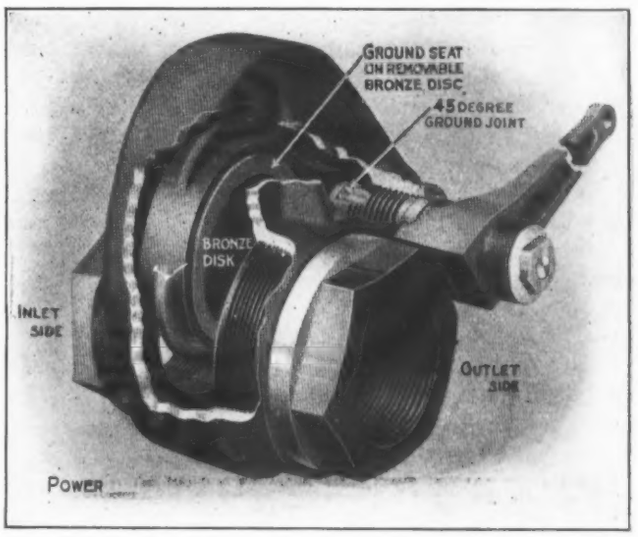


"CASSCO" PACKING

Cassco rings for air-tight packing are made with the end rings beveled to fit the stuffing-box and gland. The bars are 6 in. long, and of several sizes. They are placed lengthwise in the stuffing-box when it is warm; if the machine is not in use, a blow torch or bunsen burner should be used. The box should be filled with the packing and the gland screwed up hard to compress it into a solid ring. The packing must be kept tight until it sets, when the pressure may be removed. If there is a space around the rod at the back of the stuffing-box the beveled metallic ring shown in the illustration should be first inserted to keep the packing from being squeezed through into the cylinder. Rings of the proper size may also be used and some of the packing added, if necessary, to completely fill the stuffing-box. Cassco has been used with success on all types of engines and pumps and is specially good for machinery handling oil. It is made by the Cassco Bar-Metallic Packing Co., 8 South Dearborn St., Chicago, Ill.

"Okadee" Blowoff Valve

The blowoff valve shown in the illustration has been used on locomotives for years, but only recently has it been placed on the market for stationary and marine boilers by the Engineers Specialties Co., 333 South Dearborn St., Chicago, Ill. It is simple, has seven parts, is quick



"OKADEE" BLOWOFF VALVE

opening and has a straight through blow for sediment and water.

The valve itself is a removable disk made of gun-metal bronze, carried loosely in a yoke secured to the stem to which the operating handle is attached. The disk seats against the inner face of the hexagon nut shown in the foreground and on the opposite side against the valve body. A movement of the handle carries the yoke and the disk across the face of the opening, and when the valve is fully open the outlet is cleared. The disk is free to turn and reseat in a different position at every closing. To take out the disk it is only necessary to unscrew the hexagon nut on the outlet side. The body is of gray iron, the yoke of cast steel, the disk of gun-metal bronze, the stem of machine-tool steel and the bushing for the stem of brass.

Centrifugal Effects in Belting

By W. F. Schaphorst

Despite the fact that thousands of successfully operated slack belts are daily staring them in the face, scientists refuse to unbend to the everyday practicability of such belts. "It is written" in engineering proceedings that belts, to operate properly, must be given initial tension.

The writer admits that hard, stiff, uncared-for belts need initial tension, but belts should not be hard, stiff and uncared for. They should be made pliable, for it is acknowledged even by scientists, that in the pliable state belts are best qualified to grip the pulleys closely and they grip the pulleys to such an extent that extremely slack running is often possible. An instance has been called to my notice where a 16-in. painted canvas belt, running at a speed of 2340 ft. per min., is transmitting 300 hp. and running 30 in. slack. The computed pulling stress on this belt is therefore about 264 lb. per in. of width—an extremely high tension under any condition.

Another instance has been called to my notice where a belt tightener, listing at nearly $1000 and carrying a probable discount of 40 per cent., was used to create tension on a drive where one pulley was small and the other large. The belt was old and oily. Even the tightener did not prevent slip. A man who has had considerable belt experience was consulted. He recommended making the belt pliable, not necessarily sticky, and in a short time, after his directions had been followed, the slipping stopped. And, what is more important still, the idler is no longer needed. The belt sags 13 in.

The chief advantages of slack belts as has often been pointed out are: Increase of arc of belt contact, and decrease in bearing friction. One argument against these belts is that serious centrifugal tension is always present where speeds are high and pulleys small, and it seems that no one has ever raised a finger to refute this argument to any extent. The slack-belt enthusiasts and operators merely say when asked to explain, "Well, our belts are running, aren't they? And they run at mighty high speeds, too, without slipping, let me tell you. The proof of the pudding, etc." Elimination of slip is, of course, of greatest importance.

Centrifugal force is computed from the formula

$$C = \frac{WV^2}{gR}$$

where

W = Weight in pounds;
V = Velocity in feet per second;
g = Gravity;
R = Radius of curvature in feet.

Centrifugal force is, therefore, greatest at the smaller pulley, belt velocity being the same at all points.

Fig. 1 shows a proportion commonly observed in practice, namely, a 4-ft. driving pulley, a 1-ft. driven pulley and 20 to 25 ft. between centers. The lower half of the belt is the pulling half and the upper half is the slack or nonpulling side.

Where the nonpulling side is permitted to run slack, about as shown in Fig. 1, the weight of the belt alone, hanging in the form of a catenary, will compensate for the centrifugal force up to a considerable speed in most cases, but as soon as that speed is passed the belt mathematics we are customarily fed tells us that to overcome this high centrifugal tension, more tension must be added to the nonpulling side by drawing the shaft centers farther apart. Nothing is said about the radius R of the slack side just before passing onto the small pulley.

The tendency to "fly away" from the large pulley is seldom if ever serious at present-day speeds. The formula above tells why. The weight of the belt alone is great enough to pull itself down below the tangent line TT in which case a curve concave upward is formed between the pulleys, the inertia property causing the sharpest curvature to form close to the small pulley, thus increasing the arc of contact considerably more than when the belt is not in motion, and creating a counter centrifugal force that can be accurately computed as soon as we know the curvature at the sharpest turn. If this "slack

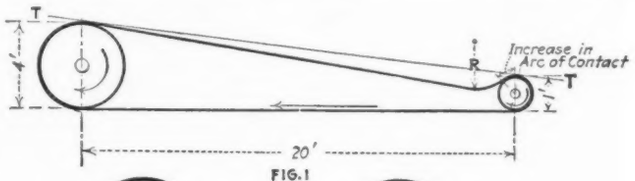


FIG. 1

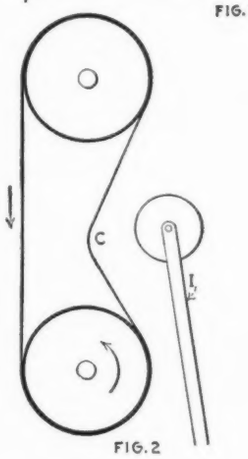


FIG. 2

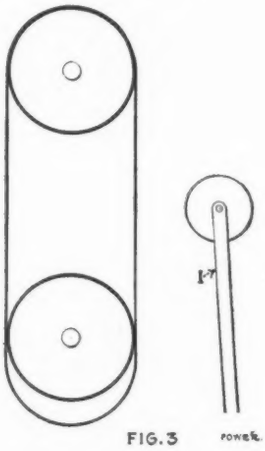


FIG. 3 POWER

curvature" is equal to the curvature of the small pulley we are justified in assuming that the ill effects of centrifugal tension are eliminated.

It has long been known that a slack curve once established in a vertical or approximately vertical belt, running at high speed, will maintain its form about as indicated in Fig. 2 and pull full load with apparent ease. It is the centrifugal force set up in the curve C that holds the belt in running position. As soon as the engine stops (usually before it stops) the belt drops to the position shown in Fig. 3. To start the drive, idler I must be used.

It would appear then that the scientific way to adjust the slackness of a slack belt is to make the loose curve as sharp as possible while the belt is in motion, and close to the small pulley. If the curvature can be made sharper than on the small pulley, all the better.

This, the writer believes, explains why slack belts are so successful at high speeds.

The "Aquitania," latest of the Cunard liners, requires a force of 339 men to handle her power equipment. Counting the chief, there are 35 engineers, 168 firemen, 16 leading firemen, 100 coalpassers and 20 oilers. This is more than one-third of the total crew.

Editorials

Repair Supplies

The cartoon this week, while lacking in "bones," is full of "meat."

Particularly apt, we think, is the application of the Old Mother Hubbard nursery ryhme to the situation found in so many plants. The engineer knows the needs and would like to supply them, but can't, and so the power plant goes hungry. If those whose business it is to provide the "bones," those responsible for the management of plants, all appreciated the importance of keeping the repair supplies "cupboards" filled, the engineers would never find them "bare."

Another familiar old jingle is the one that shows how "for the want of a nail," "a kingdom was lost." It is no exaggeration to say that for the want of some very inexpensive supply parts, important pieces of plant equipment have gone to rack and ruin. Worse than that, accidents have happened that resulted in loss of life and property which could have been prevented had the proper repair supplies been available.

When we urge that the power-plant repair locker should not be allowed to get into the depleted condition represented in the cartoon, we mean it to apply not only to expendable supplies, but to tools, for a suitable kit of tools belongs in the locker when not in actual use. To be shy of either tools or supplies is usually a policy of saving pennies and wasting dollars. A high-priced packing, for example, may be used where another, costing much less, would answer as well or better. Inversely, a low-grade packing may be applied on a high-speed piston in the absence of a suitable kind, which will ruin the rod or cause a shutdown, the far-reaching effect of which is hard to estimate.

The engineer cannot be expected to keep his plant in the best condition without tools and supplies. The value of the extra time on one job, in many instances, will be greater than the cost of suitable tools, even if they were thrown away after once using.

In many plants, the scrap pile is depended upon for pipe-line material, such as fittings, valves and even pipe lengths. An extension of piping made up from such junk is very apt to develop leaks in the fittings and pin holes in the piping. Here extra gage glasses are unknown; pump and engine packing is missing, and consequently odd sizes are cut down to fit the valve stem or piston rod.

Following are instances of neglect of the kind we deplore: One lighting plant contained three generating units, using eight wire-mesh copper brushes each. There was no reserve stock and new brushes were bought only six at a time, not enough for one machine.

Think of this as actually happening! An engineer, unable to obtain the proper piston-rod packing, made his own packing from the lower extremity of his work shirt and tallow. It stopped the steam from blowing nearly to the crank, although, of course, it was short-lived.

Such little things as valve disks are lacking in many plants when wanted, due to the "penny-wise-and-pound-foolish" policies of the management.

In a certain plant, the blowoff valve (there was but one) of a boiler began leaking so badly that it was difficult to keep the proper water level, and finally the boiler had to be cut out of service for the remainder of the run. The disk was cracked and broken, and had been for some time, but there were no disks on hand. The boiler had to be operated, and consequently the manage was forced to purchase a few disks.

No argument is needed to show that such conditions are all wrong. It is generally thoughtlessness or carelessness that is responsible.

The needful thing is to get those who must pass on the engineers' requisitions for supplies to appreciate that a good stock is not an extravagance, but a real investment. With the plant kept up to the best condition, it will operate most economically. "A stitch in time saves nine," and a little repair made as soon as it is needed will forestall a costly overhaul when the seed of neglect sprouts into a breakdown. A third profit is a larger realization on the expenditure for plant help. Given the facilities, the engineer and his assistants will gladly do many little things that would run into money if outside labor were employed to do them.

Monuments of the Seas

It is a far cry, back three centuries, to the time when Hudson sailed the "Half Moon" up the river that bears his name. Two centuries later the steam-propelled "Clermont" followed the course of the "Half Moon" up the stream now agitated by many craft of commerce.

Like a pebble dropped in a lake, these marine wonders of their days have gone, and little more than pages of history remain to tell of their existence, the memory of them fading like the ripple where the pebble dropped. As these craft disappear over the horizon of Time to make history, new maritime wonders appear.

Thrillingly the daily press now tells of how the "Vanitie," a racing yacht contesting to defend the cup in the coming races, tore over ten miles of sea in the short time of one hour, sixteen minutes and fifteen seconds—not quite eight miles in an hour is the best that can be done by the finest example of sailing craft that yachtmen can produce. The "Aquitania," breaking all records for a maiden voyage, exceeded the guaranteed speed of twenty-three and one-half knots (twenty-six and one-half miles) an hour, over three times as fast as the "Vanitie," and kept it up over the three thousand miles of sea separating the ports between which she plies.

It is power, steam power, that makes this difference possible—a higher development of the same forces that drove the old "Clermont" up the Hudson at a speed that would shame the skipper of a towing tug. It is steam power that makes the trips across the oceans matters of a few days instead of months. It is power that gives to

the passenger the benefits of electric light, of well ventilated quarters; that preserves his foods and makes wireless telegraphy a commercial success.

Truly, these modern palaces of the seas are monuments to the engineering skill that designs and manages them.

Municipal Isolated-Plant Scheme Relinquished

At Springfield, Mass., it was proposed to install a municipal isolated electric plant for the city buildings in the urban center. After serious consideration, the United Electric Light Co. has offered to supply current at four cents per kilowatt-hour as against the seven cents previously charged. This saving to the city is estimated to be $7500. Curiously, this four-cent rate only applies to a few of the city's buildings while the others are still charged the seven-cent rate. Why? Probably no plant was *proposed* for these other buildings. Would it not be the part of good tactics to *propose* a plant for the remaining buildings now, and secure a reduced rate for them also? It looks like easy money.

Incidentally, it would be interesting to know just how far the *proposing* had to proceed before the company "came across" with its reduced rate, and also what new equipment or efficiency engineering makes it possible to sell this particular part of the company's output at a rate lower than before. One rate or the other must be perforce juggled.

Contracts for electric service are sometimes fearfully and wonderfully made. For example, one of the terms of the contract under which the Federal Government in the District of Columbia gets current during six months of the year (April to September inclusive), at the rate of two and a half cents per kilowatt-hour *in buildings having their own generating plants,* provides that should those same buildings require any street service whatever during the remaining six months they will pay six cents for it (up to a certain amount used) and also at the rate of six cents for *all current used* at the two and one-half-cent rate during the fiscal year.

In other words, suppose $5000 worth of the two and and one-half-cent current had been used, and it was desirable to use street current for a short time during the winter, there would be due the company by the terms of this contract $7000 back pay *in addition* to the amount of the bill for the winter current at six cents. This contract is in force at the present time.

Power-Plant Economics

At various times POWER has warned against getting in a "rut" in the managing of the plant. This "rutty" habit still prevails to a large extent and not in the small plants alone. In the large, well equipped station, where one would expect to find plenty of initiative and "go," it is the rule to find routine paramount to all else; that routine is mistaken for watchfulness.

Ask the man in charge of the boiler plant how many boilers are necessary to carry a certain load most economically, and you will often receive a vague and unsatisfactory reply. Inquire as to the percentage of CO_2 in the stack gases under certain load conditions, and you will probably receive a similar answer.

Look up the chief and ask him about the scale in the boilers. Find out if he has a full understanding of the heat losses possible through the presence of scale in the boilers. He will acknowledge that the loss is large, but generally he can only guess as to just *how* large it is. Of course, the boilers are cleaned at regular stated intervals; that is part of the routine. The scale is removed from the boilers and—what more can one expect? At the same time, it will probably be noticed that there is no means of treating or softening the feed-water supply and no one on the job capable of directing feed-water treatment. So the boilers are allowed to remain in service for a certain length of time, and then they are cleaned.

At many plants throughout the country at least two per cent. of the fuel consumed could be saved merely by treating the boiler-feed water and so reducing the amount of scale in the boilers. A plant burning five hundred tons of coal per day, for instance, could save ten tons every day, which in a year would represent quite a sum. The power-plant operatives are not to be criticised for existing conditions. They are going about things in the conventional manner, doing things the same as they have always been done, in the same way that they would be done in the plant next door.

Often it is the owners, and those in charge of the management, who are directly responsible for the losses which are continually taking place through their neglect to supply men capable of exercising technical control of these features of power-plant operation. And for the reason that the technical man demands, and receives, a just compensation for his services.

When the fireman says, "Boss, what percentage of CO_2 do you want today?" watch out that the steam doesn't go down just when you need it most—and don't fire the fireman. He knows his business.

Jack London tells of a cook that was fed to the sharks because he wouldn't keep himself clean. Well, how about the fellow who lets the flue fill with soot until there isn't draft enough to carry the load?

If there's anything a man should be called down for, it's letting steam blow out of the back-pressure valve at the same time the live steam is blowing into the heating system.

Some engineers think you don't need a separator on a superheated steam line. Bet they never listened much when they started the unit on the line. Sometimes it sounds like a man gargling his throat.

Waxing enthusiastic over the report of the Committee on Progress of the National Electric Light Association, a metropolitan daily says, "Although steam had centuries the start, electricity already yields one-fourth the industrial power of the United States, and the prediction is made that it will rapidly yield over four-fifths, forcing steam into the background." Let the "dailies" remember that, neglecting water power, for every horsepower output increase of electricity, there is more than a horsepower increase in steam somewhere. Electricity must be generated; it does not grow like weeds.

Engineers' Study Course

Elementary Mechanics--XIV

LAST LESSON'S ANSWERS

56. There are two ropes passing over the pulley A, Fig. 51, and the tension in each rope is 80 lb. Hence the weight that could be placed on the pulley A would equal

$$80 \times 2 = 160 \text{ } lb.$$

57. Since there are four sheaves on the movable block, Fig. 52, there would be $4 \times 2 = 8$ ropes passing over the movable pulley. The pull in each rope is 100 lb. Therefore, the weight W would equal

$$8 \times 100 = 800 \text{ } lb.$$

58. There would be five sheaves on the fixed block as will be evident from a careful inspection of Fig. 54 where for the sake of clearness the sheaves are made of varying diameter. The rope is attached to the movable block at the point A, passes over the first sheave B of the fixed block, thence to the sheave C of the movable block and so on until the rope leaves the last sheave D on the fixed block. There are nine ropes supporting the movable block and hence the weight W equals

$$9 \times 100 = 900 \text{ } lb.$$

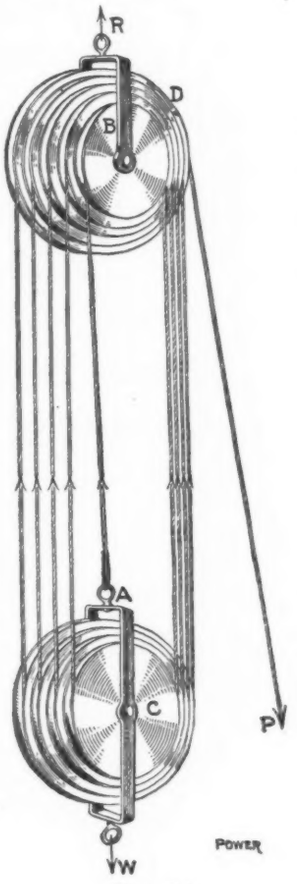


FIG. 54.

59. In problem 57 the reaction R on the hook equals the sum of the weight W and the effort P or

$$R = 800 + 100 = 900 \text{ } lb.$$

In problem 58 the reaction R on the hook is

$$900 + 100 = 1000 \text{ } lb.$$

60. From equation (20)

$$W = \frac{2 \times P \times R}{(R - r)}$$

where

$P = 100$ lb.;
$R = 8$ in.;
$r = 7$ in.

Hence

$$W = \frac{2 \times 100 \times 8}{(8 - 7)} = 1600 \text{ } lb.$$

FRICTION

When an attempt is made to slide one body over another a certain resistance is encountered which must be overcome before the body will move. This force which tends to prevent the motion of one body on another is called the *force of friction* or simply the *friction* between the bodies. The amount of this friction will depend upon the nature of the surfaces in contact, and the materials of which the bodies are made. No matter how smooth or regular the surfaces in contact, this force of friction will always be present to counteract the forces tending to move the bodies. Thus in Fig. 55 let the body A weighing W pounds rest upon a table. Attached to the weight A is a cord passing over the pulley shown. Let the force F be increased until the body A is just on the point of moving. It must be evident that the horizontal pull in the cord is equal to the force F, and hence the resistance between the body A and the table is equal to the force F and acts in a direction opposite to this force.

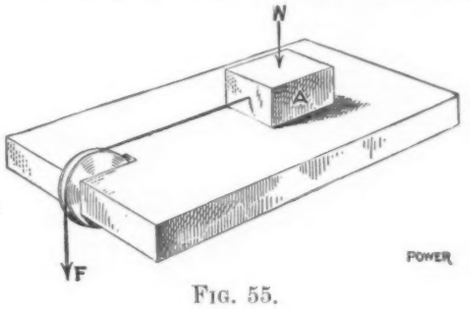


FIG. 55.

The *force of friction will always act in a direction opposite to that in which the body tends to move.* When the body A is just on the point of moving the force F is called the *limiting* or *static friction* between the body and the table. The force required to keep the body in a state of uniform motion is found by experiment to be less than the force which is required to put the body in motion. However, when the body is once in motion the force of friction between the body and the table is called the *sliding friction* and in all cases this will be less than the static or limiting friction.

In Fig. 55 it will be noted that the weight W is acting at right angles to the direction of motion of the body A. *The force or pressure which acts at right angles to the direction of motion of a given body is called the normal pressure between the given body and the surface over which it tends to move.* The greater this normal pressure the greater will be the friction between the given bodies, and the greater will be the force F required to move the body A in Fig. 55.

The ratio between the force of friction, or the force which is just great enough to put a given body in motion, and the normal pressure is called the *coefficient of friction of rest.* Thus,let

F = Force required to put the body in motion;
N = Normal pressure between the given bodies;
f = Coefficient of friction of rest.

Then from the above definition

$$f = \frac{F}{N} \qquad (21)$$

or

$$F = f \times N \qquad (22)$$

If a force of 50 lb. will move a weight of 200 lb. the coefficient of friction f will equal

$$\frac{F}{N} = \frac{50}{200} = 0.25$$

If, in equation (21), F represents the force that will produce uniform motion of the body A along the table, then the value of f will be called the *coefficient of friction of motion,* and this is the value commonly given in tables.

A simple apparatus for determining this coefficient is shown in Fig. 56, which consists of a smooth plate CB of a given material, on which is placed a body A of some other material. The wedge D is forced under the plane CB until a slight tap on the weight A starts it down the plane with *uniform motion.* The angle BCX = angle a is then carefully measured. Let the line RS represent to scale the given weight W, and let this weight be resolved into two components RT and TS, the former being at right angles to the plane CB and the latter being parallel to the plane. The effective force causing motion down the plane is therefore the component TS, which is the force of gravity acting parallel to the plane. The component RT causes no motion, but is the normal pressure between the weight W and the plane CB. This normal pressure N produces a force of friction F which acts parallel to the plane and tends to hold the body A at rest. Now from equation (22) the force of friction F is equal to the product of the coefficient of friction times the normal pressure N. For equilibrium to exist the force of gravity G acting down the plane must equal the force of friction F, which is acting up the plane or $F = G$. The angle SRT is equal to the angle BCX or the angle a, since the line RT is perpendicular to the line CB, and the line RS is perpendicular to the line CX. Also the component $TS = W \times \sin a = G$ and the component $RT = W \times \cos a = N$. Therefore, since $F = G$,

$$W \times \sin a = W \times \cos a \; xf$$

or

$$f = \frac{W \times \sin a}{W \times \cos a} = \tan a \qquad (23)$$

[Note—The sine of an angle divided by the cosine of the angle equals the tangent of the angle. See the lesson, Trigonometry—III, Dec. 9, 1913.—Editor.]

Hence the coefficient of friction f is the tangent of the angle a at which the plane CB must be inclined to produce uniform motion of the body A down the plane. The angle a is called the *angle of friction.* The force of friction F is practically independent of the area of the surfaces in contact.

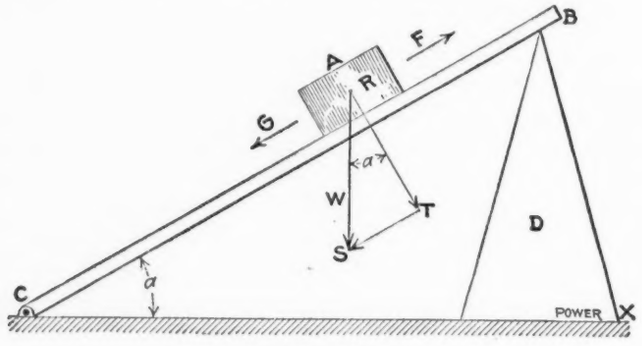


FIG. 56.

STUDY QUESTIONS

61. A cast-iron body weighing 200 lb. rests upon a horizontal steel plate. If the coefficient of friction is 0.28, what force will be necessary to move the casting?

62. Is the force necessary to raise a body from the ground the same as the force required to move the body along the ground? Give a reason for your answer.

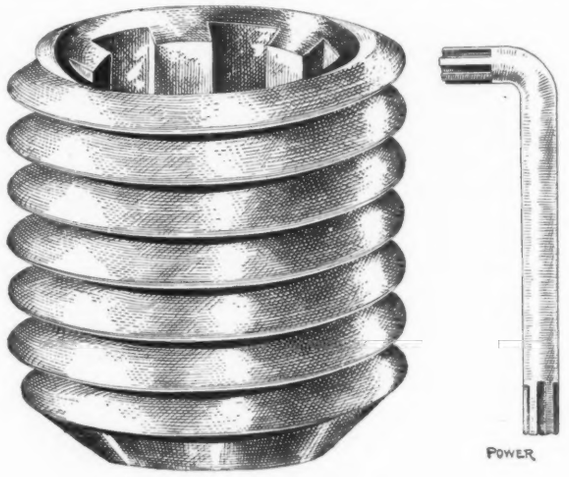
63. During a given experiment with the apparatus shown in Fig. 56 the angle a was found to be 15 deg. What was the coefficient of friction between the plane and the body A?

64. A railway car weighing 60,000 lb. requires a force of 600 lb. to keep it in a state of uniform motion along a horizontal track. What is the coefficient of friction between the wheels and the track, neglecting the friction at the journals?

65. At what angle would it be necessary to incline a given plane so that a given body whose coefficient of friction was 0.3 would move down the plane with a uniform speed?

Bristo Safety Setscrew

The accompanying illustration is a view of the Bristo safety setscrew and the wrench for setting it up. The hollow head is equipped with six dovetailed slots, into which corresponding projections of the wrench fit. When the setscrew is set up there is no tendency for the wrench



SAFETY SETSCREW

to expand or split the screw, but there is for the wrench to contract ahead on account of the angles of the face of the dovetailed flutes. As the setscrew, when in place, does not project above the hub of the pulley, etc., it thus eliminates a source of danger to the workmen.

This setscrew is manufactured by the Bristol Co., Waterbury, Conn., and is made in sizes from ¼ to an inch in diameter, with U. S. standard threads, for all stock sizes, and can be furnished in sets of round, flat, conical and dog point, instead of the cup point shown.

Globe Valves for Superheated Steam in Europe—Some time since, "Power" was called upon to verify the statement that globe valves were exclusively used for superheated steam in Europe, on account of the liability to distortion of gate valves with the high excessive changes in temperature. We referred the question to Dr. ing. h. c. Wilhelm Schmit, the eminent authority upon superheaters, and are advised by him that "In Germany globe valves have always been used nearly exclusively for saturated as well as for superheated steam. The use of gate valves for this purpose has been quite exceptional. So far as I know, other European countries follow the same practice. I do not know of any bad experiences with gate valves, as I do not know of any case in which this gate has been used with superheated steam. Over here, gate valves are used for the most part only in connection with water, gas and exhaust-steam piping."

Tests of the Taylor Stoker in Moderate Sizes*

BY HORACE JUDD

Much is being said about the high overload efficiency to be expected from the underfeed type of mechanical stoker, and the results of a number of carefully made tests have been presented to the public during the past few years showing remarkable efficiency and economy for this type of furnace.

The trials thus reported have, for the most part, been conducted under favorable conditions, with the boilers and furnaces often of unusually large sizes, which have been operated under expert guidance. In view of this, it has frequently been a query with interested power-plant men whether the stoker in units of moderate size would give the same favorable showing when tended by the average fireman.

During the past year the writer has had an opportunity to make a series of evaporative tests on a 250-hp. Babcock & Wilcox boiler and a 300-hp. Flanner boiler, each equipped with a three-retort Taylor stoker. Four different kinds of coal were used and the only instructions to the firemen were to run the furnace and boiler as usual and as if no boiler trial were in progress.

TABLE 1. AVERAGE DATA AND RESULTS OF EVAPORATION TESTS

1 Kind of furnace—Three-retort Taylor Gravity Underfeed Stoker										
2 Kind of boiler—Babcock & Wilcox Cross-Drum, Water Tube							Flannery, Cross-Drum, Water-Tube			
3 Grate surface—41 sq.ft.							45 sq.ft.			
4 Heating surface—Boiler 2485 sq.ft. Economizer 2040 sq.ft.							3130 sq.ft.			
5 No. of trial	1	2	3	4	5	6	7	8	9	10
6 Date	3-20-13	3-21-13	3-22-13	3-24-13	3-25-13	3-27-13	4-9-14	5-18-14	5-22-14	6-2-14
7 Duration, hr.	10	10	10	10	10	10	10	10	10	10
Average pressures										
8 Barometer	29.01	28.58	29.74	29.08	28.89	28.94	29.46	29.82	29.32	29.55
9 Boiler gage	96.8	96.5	96.0	99.7	97.6	99.5	123.8	115.1	118.3	123.8
10 Tuyere box	1.50	1.45	1.30	1.80	2.42	1.90	1.48	1.66	2.76	....
11 Draft over fire	0.125	0.09	0.16	0.15	0.16	0.19	0.045	0.03	0.038	0.023
12 Draft leaving boiler	0.32	0.42	0.34	0.31	0.39	0.44	0.24	0.25	0.32	0.34
13 Draft entering economizer	0.71	0.73	0.74	0.74	0.89	0.75	....	....	....	....
14 Draft leaving economizer	....	0.78	0.81	0.80	1.10	1.14	....	....	....	....
Average temp.										
15 Fire room	88	84	78	80	87	76	71	94	96	95.5
16 Flue gas leaving boiler	745	705	664	711	710	657	450	466	485	664
17 Flue gas entering economizer	541	501	508	543	530	507	....	....	....	....
18 Flue gas leaving economizer	274	271	269	278	265	249	....	....	....	....
19 Feed water entering economizer	147	144	140	145	134	121	....	....	....	....
20 Feed water leaving economizer	170	169	180	171	165	157	....	....	....	....
21 Feed water entering boiler	162	161	170	160	152	143	54	192	69	75
Analysis of Coal as fired	West Va.	Splint	Hocking			Pitts. No. 8	West Virginia Fairmont District		West Va. Thacker Coal Field Washed	
Grade			Nut, pea and slack				Nut and pea			
22 Moisture	4.42	4.66	9.40	11.62	6.31	3.79	6.31	3.90	2.73	6.09
23 Carbon	70.74	64.48	63.25	60.23	66.57	69.21	66.39	71.59	71.95	70.47
24 Hydrogen	5.10	4.98	5.16	5.21	5.22	5.12	5.01	4.98	4.87	5.42
25 Oxygen	11.49	11.46	17.13	18.69	12.31	10.33	13.76	9.93	8.93	12.90
26 Nitrogen	1.31	1.27	1.19	1.12	1.16	1.21	1.10	1.14	1.14	1.49
27 Sulphur	1.06	1.58	1.08	0.85	3.64	3.56	2.79	2.42	3.36	1.10
28 Ash	10.30	12.33	12.19	13.90	11.10	10.57	10.95	9.94	9.75	8.62
28A Combustible in refuse	19.19	29.89	22.77	17.57	25.89	28.55	25.50	41.50	48.53	22.89
29 Unburned coal	2.73	5.94	5.34	3.44	4.30	4.70	4.21	7.83	10.17	....
30 Heating value, coal	12,697	12,375	11,164	10,570	12,067	12,582	12,184	12,830	13,120	12,744
31 Heating value, combustible	14,889	14,890	14,244	14,191	14,625	14,692	14,700	.....	14,980	14,950

LOCATION OF PLANTS

Six of the trials were conducted in March, 1913, on a 250-hp. Babcock & Wilcox boiler of the cross-drum type forming the boiler equipment at the Troy Laundering Co., Columbus, Ohio; and three of the trials were made on a 300-hp. Flanner boiler also of the cross-drum type, at the power plant of the Ohio State University, Columbus, Ohio. The boilers at both places were equipped with three-retort stokers.

The boiler trials at the laundry were carried on under the writer's direction in coöperation with Messrs. C. C. Brown, H. B. Craft and W. O. Durbin, members of the graduating class of 1913 in mechanical engineering at the Ohio State University, who incorporated the results of the trials in their graduating thesis.

The coals used were representative soft coals from the different fields lying in or adjacent to the Ohio fields and were as follows:

West Va. splint, nut, pea and slack, $2.40 per ton delivered.
Hocking, nut, pea and slack, $1.65 per ton delivered.
Pittsburgh No. 8 nut, pea, and slack, $2.20 per ton delivered.

THE BOILERS

The boiler is one of the Babcock & Wilcox cross-drum marine type, with vertical headers connected by 120 four-inch tubes (12 wide and 10 high) inclined from front to back and 17 feet 8 inches long. A steam drum 42 inches diameter and 9 feet 10 inches long is placed transversely over the rear header, to which it is connected by 12 4-inch circulating tubes, 3 feet 4 inches long. This drum is also connected to the front header by 12 four-inch horizontal tubes 15 feet 11 inches long, with the normal water level at the center of these tubes. The total heating surface is 2485 sq.ft., giving a builders' rating of 248.5 boiler horsepower. There are the usual three transverse passes for the flue gases through the boiler, the first baffle wall being a continuation of the back wall of the furnace and the second baffle extending down from above to the third row of tubes from the bottom.

The flue gases were passed to a Green fuel economizer having 160 four-inch tubes giving 2040 sq.ft. of heating surface. To provide ample draft facilities, the economizer is equipped with a 120-inch induced draft fan. The economizer is of unusually large size, its surface being over 82 per cent. of the boiler heating surface, to give a large storage capacity of hot water for laundry use.

At the university, the boiler tested is one of a battery of two, of the horizontal cross-drum, water-tube type known as the Flanner. It has 180 three-inch tubes 18 ft. long, 36 three-inch tubes 10 feet 8 inches long and 36 three-inch tubes 5 feet 3 inches long. These latter connect the front and rear headers to the steam drum, 54 inches diameter, 10 ft. long, which is placed transversely and nearly over the center of the rear half of the boiler. It has 3130 sq.ft. heating surface, with three transverse passes for the flue gases. This boiler is a part of the university boiler equipment, amounting in all to about 2000 rated boiler hp., all of which, with the exception of those recently installed and equipped with Taylor stokers, are operated wholly on natural draft.

METHOD OF CONDUCTING THE TESTS

During the boiler trials, excepting Nos. 8 and 9, the fireman followed the customary routine of operation, using his own judgment as to the proper thickness of fire, draft and time of dumping ashes. The tubes were blown about two hours previous to each test. At the laundry ten hours is the average length of time during which a steam supply is needed. Ten hours was therefore taken as the duration of trial, with readings every fifteen minutes excepting for the coal and water, which were weighed out as needed, and for the flue-gas analyses, which were taken every half-hour from a continuously drawn sample. All such readings were totaled or averaged for the entire run; the results are to be found on the observed data and result sheets (Tables 1 and 2).

These results, where necessary, are corrected for errors

*From a paper presented before the Ohio Society of Mechanical, Electrical and Steam Engineers, June 1914, at Sandusky, Ohio.

due to the instruments, and the principal results as given are arranged in the order of the code recommended for boiler trials by the A. S. M. E. The tuyere box pressure in inches of water was taken by a U-tube manometer; the draft pressures, by Ellison differential draft gages; the flue temperatures, by 1000 degrees F. Hohmann & Maurer mercury pyrometers, with 5-degree divisions; all other temperatures, by the ordinary chemical thermometer with two-degree divisions excepting the feed-water thermometer, which was graduated to read degrees. The coal and water were weighed on platform scales of 1200-pound capacity capable of being read to within one-half pound.

Coal samples were taken from each barrow or bucket of coal, amounting in all to about 500 pounds per trial. These samples were analyzed for moisture, ash and sulphur and the heating value was found by a Mahler calorimeter. In trial No. 7, the ultimate analysis was also found, but for the other cases the ultimates were figured from a known average ultimate analysis from the same vein of coal. The combustible in the ash was found from a sample of the refuse and ash in the ash pit. The percentage of unburned coal was found by the expression

$$d = \frac{a\,c}{(1-a)\,(1-c)}$$

Where d = Per cent. of unburned coal in total coal as fired.
a = Per cent. of ash by analysis in total coal as fired.
c = Per cent. of combustible in refuse from ash pit.

depend largely upon the clinkering properties of the coal. If the coal has an ash easily fusible under the action of the high furnace temperature and the increased air blast necessary for high overload operation, the clinker will prove troublesome by choking the grates and retarding the draft.

TABLE 3

Trial No.	Kind of Coal	Interval between Dumps, Hr.	Per Cent. Unburned Coal	Per Cent. Sulphur
1.....	W. Va. Splint	2.5	2.73	1.06
2.....	W. Va. Splint	2.5	5.94	1.58
			Av. 4.34	Av. 1.32
3.....	Hocking	2	5.34	1.08
4.....	Hocking	2	3.44	0.85
			Av. 4.39	Av. 0.97
5.....	Pitts. No. 8	3	4.30	3.64
6.....	Pitts. No. 8	3	4.70	3.56
			Av. 4.50	Av. 3.60
7.....	W. Va., Fairmont District	2.4	4.21	2.79
8.....	W. Va., Fairmont District	1	7.83	2.42
9.....	W. Va. (washed), from Thacker coal fields	1	10.17	3.36
10....	Thacker nut and pea	2.5	2.3	1.10

For dump periods ranging from two to three hourse (Table 3) the percentage of unburned coal passing into the ash pit averaged 4.36% for Trials 1 to 7.

For Trials 8 and 9 with one hour dump periods the average unburned coal loss was 9 per cent., showing that the unburned coal loss varied about inversely as the length of the dump interval.

While the presence of sulphur in the coal may not have, as some claim, any great effect on the clinker formation, it was found at the laundry that the third kind of coal used (Pitts. No. 8), containg 3.6 per cent. sulphur, gave the most trouble from clinkering and, in addition, when the refuse was dumped or when the fan was slowed down temporarily, the sulphur fumes became almost unbearable.

UNBURNED COAL—The amount of unburned coal (Table 3) present in the ashpit refuse is influenced by the rate of coal feed, the number of dumps made and the degree to which the coal clinkers. If the coal is fed too fast, some of the coke may be pushed forward onto the dump plate where the air supply may be insufficient to burn it completely. When the refuse is allowed to accumulate too long, some of the coke may also become buried under the ash and clinker. The clinker, if easily fused, may run down and envelop some of the unconsumed coal. For the Pitts. No. 8 coal, with a three-hour dump interval, more trouble was experienced with clinker formation and a larger percentage of unburned coal was present in the refuse.

UNIFORM COAL FEED—The coal feed is uniform and positive and under control through the speed regulator on the fan engine. The rate of feed can be approximately determined by noting the revolutions of the upper rams, since

TABLE 2. AVERAGE DATA AND RESULTS OF EVAPORATE TESTS

No. of trial	1	2	3	4	5	6	7	8	9	10
Coal per hr.										
32 Fired per hr.	1612	1576	1595	1943	1825	1747	1601	2076	2528	2476
33 Per sq.ft. grate	49.1	47.8	48.4	58.9	55.3	53.1	48.5	46.0	56.2	55.1
34 Combustible burned per hr.	1338	1230	1168	1397	1441	1425	1265	....	1988	2050
35 R.p.hr. stoker crank shaft	36	32.8	36.3	41	38.4	37.8	38.5	41.7	51.8	....
36 Coal per retort per revolution	15.0	16.1	14.8	15.8	15.9	15.9	15.8	16.6	17.3	....
37 Coal per hr. per boiler hp.	3.78	3.72	4.31	4.73	4.19	4.21	4.06	3.96	4.34	....
Water per hr.										
38 Fed to boiler, lb.	13,723	13,657	12,054	13,280	13,966	13,255	11,255	11,309	....	....
39 Quality of steam	98.5	97.7	98.2	97.9	97.9	97.8	99.0	99.0	99.4	99.3
40 Equivalent dry steam, lb.	13,516	13,334	11,834	12,995	13,668	12,964	11,279	....	16,865	....
41 Factor of evaporation	1.091	1.092	1.083	1.093	1.101	1.110	1.206	....	1.192	....
42 Equiv. evaporation from and at 212°, lb.	14,741	14,590	12,808	14,204	15,049	14,390	13,603	....	20,105	21,877
43 Equiv. evap. per sq.ft. heating surface, lb.	5.90	5.84	5.12	5.68	6.02	5.76	4.33	....	6.38	....
43A Cost per 1000 lb. equiv. evaporation	13.12c.	12.96c.	10.27c.	11.29c.	13.36c.	13.34c.	....	....	....	....
Horsepower										
44 Developed	426	423	371	411	436	415	394	524	583	635
45 Builders rating	248.5	248.5	248.5	248.5	248.5	248.5	313	313	313	313
46 Per cent. builders rating	172	171	149	165	176	167	126	167	186	203
Economic Results										
47 Water fed per lb. actual coal, lb.	8.52	8.67	7.56	6.84	7.66	7.50	7.13	....	6.71	7.55
48 Equiv. evaporation per lb. actual coal, lb.	9.15	9.26	8.03	7.31	8.25	8.24	8.49	8.71	7.96	8.95
49 Equivalent evaporation per lb. combustible burned, lb.	11.02	11.86	10.97	10.17	10.45	10.09	10.75	....	10.11	10.68
Efficiency										
50 Boiler and furnace, per cent.	71.8	77.3	74.7	69.4	69.3	66.7	71.0	....	66	68.1
51 Boiler, furnace and grate, per cent.	69.9	72.5	69.9	67.1	66.3	63.5	67.6	65.8	59.0	....
Flue gas per cent. by vol.										
52 Carbon dioxide	15.20	14.20	13.50	14.70	12.40	12.10	10.84	12.95	11.97	14.60
53 Oxygen	3.46	5.22	5.50	2.30	5.51	5.20	8.32	5.33	4.52	2.70
54 Carbon monoxide	0.39	0.40	0.09	0.70	0.05	0.15	0.13	0.40	0.91	0.25
55 Per cent. excess air	19.4	33.6	34.9	12.0	34.4	31.6	65.2	33.0	26.3	....
56 Air req. per lb. coal	8.9	8.6	8.2	7.6	8.3	9.0	8.5	....	8.5	....
Heat losses, per cent.										
57 Latent heat	3.54	3.53	4.17	4.43	3.85	3.61	3.66	3.33	3.10	3.84
58 Carbon monoxide	1.38	1.40	0.36	2.67	0.24	0.66	0.63	1.61	3.53	1.29
59 Products of combustion	12.71	11.95	11.69	12.69	11.99	11.42	7.77	6.92	6.91	11.19
60 Excess air	2.11	3.42	3.54	1.28	3.51	3.13	3.99	2.02	1.57	1.37
61 Radiation, etc.	7.19	1.25	5.65	8.39	9.75	12.93	12.17	12.48	15.82	11.41
62 Per cent. black smoke by chart	13.1	17.0	5.0	15.7	12.7	13.8	....	....	....	15.0

The percentage of moisture in the steam was obtained by a Barrus throttling calorimeter attached to the steam pipe near the steam outlet to the boiler.

The efficiency of the boiler and furnace is taken to be the heat actually absorbed by the water evaporated by one pound of combustible burned, divided by the heating value of one pound of combustible.

The efficiency of the boiler, furnace, and grate is taken to be the heat absorbed by the water evaporated by one pound of coal as fired, divided by the heating value of one pound of actual coal.

DISCUSSION OF THE PRINCIPAL RESULTS

The results obtained from the trials at the laundry indicate on the whole a satisfactory performance for a boiler equipment of the smaller sized unit when operated under overload conditions with the ordinary care of the average fireman.

The side cleaning doors bring the ash bed within easy view, and the rocking and jarring action of the extension grate in most cases will be sufficient to break up the clinker preparatory to dumping. The extension grate when raised to its highest position not only prevents the coal bed from sliding forward when the dump plate is down, but makes it possible to feed the coal continuously during the dumping period, thus keeping up the steam pressure.

The ease with which the dumping process is managed will

each ram plunger forms a displacement meter and for the same kind and grade of coal will discharge nearly the same weight of coal per revolution of plunger. For the grade used in Trials 1 to 7 inclusive, the amount fed per retort per revolution of the stoker shaft ranged from 14.8 pounds to 16.1 pounds, with an average of 15.7 pounds.

For the different kinds of coal used the average rates of combustion are given in Table 4.

TABLE 4

Trial No.	Kind of Coal	Lb. per Retort per Revolution	Rev. of Stoker per Hr.	Coal per Hr. per Sq.Ft. Grate	Coal per Hr. per Boiler Hp.
1.....	West Va. splint	15.0	36.0	39.3	3.78
2.....	West Va. splint	16.1	32.8	38.4	3.72
3.....	Hocking	14.8	36.3	39.0	4.31
4.....	Hocking	15.8	41.0	47.5	4.73
5.....	Pitts. No. 8	15.9	38.4	44.5	4.19
6.....	Pitts. No. 8	15.9	36.8	42.8	4.21
7.....	West Va., Fairmont Region	15.8	38.5	35.6	4.06
8.....	West Va., Fairmont Region	16.6	41.7	46.0	3.96
9.....	West Va. (washed), Thacker coal fields	17.3	51.8	56.2	4.36
10....	Thacker nut and pea	15.3	53.9	55.1	3.90

AIR REGULATION AND AIR EXCESS—Close air regulation is also possible and the proper amount is supplied entirely by means of the forced draft fan. For a given coal it is necessary only to determine the required amount of draft over the fire to secure good combustion conditions as shown by the flue-gas analysis. This is chiefly a matter of obtaining the right speed ratio between the fan engine and the stoker shaft. When the proper air supply is secured, it can be so maintained independent to some extent of the rate of combustion since the coal feed and air supply are both controlled by the fan-engine governor. Occasionally, the fireman may find it necessary in maintaining a uniform draft over the fire to adjust the damper in the air pipe leading to the windbox; but most of the regulation may be made at the flue damper. The tuyere box pressure should remain nearly constant for a given rate of combustion and draft over the fire; increasing with a higher rate of coal feed. Should it be necessary to increase the tuyere box pressure to get the proper draft over the fire, other conditions remaining constant, it would indicate that the fire bed was becoming clogged and that the air supply was restricted by clinker formation.

Where a CO_2 recording apparatus is available, the condition of the fire may be more closely watched and the air supply may be kept down to the point where carbon monoxide begins to appear.

During the tests at the laundry, owing to the extremely variable load, the draft over the fire showed a wide instantaneous variation ranging from a pressure slightly above zero to as much as ½ inch suction, though the average results are fairly uniform, varying from 0.09 inch to 0.19 inch. This could be improved by placing the induced draft fan at the economizer and the stoker fan under the same speed control which would tend to a more evenly balanced draft.

At the university the fireman was aided in the management of the stoker by a General Electric steam flow meter near by, which indicated the output of the boiler, and also by a gage showing the amount of draft carried over the fire. For trial No. 7 this gage varied from zero to 0.15 inch suction with an average of 0.045 inch.

This close air regulation, together with the fact that the air in passing through the tuyeres is preheated, and also because of the fairly large combustion chamber, will result in a high furnace temperature; consequently a more complete state of combustion is secured with good smokeless conditions.

The smoke observations as given on Table 5 were taken with a Ringelmann smoke chart at the heaviest load period during each day's run at the laundry and show about the same degree of density for each day. The smoke was light in color and in general was only slightly darker with the increase in load. The percentage of black smoke by the chart ranged from 5 to 17 per cent. The flue-gas analyses showed that these nearly smokeless conditions had been accompanied by small percentage only of excess air, which dropped as low as 12 and never exceeded 35 per cent.

It will also be seen from Table 5 that for Trials 1 to 6 the amount of CO_2 ranges from 12 to 15 per cent., with a corresponding drop in the percentage of oxygen of from 5.5 to 2.5 per cent. and a CO content varying inversely as the oxygen.

Table 6 gives a few individual flue-gas readings as taken during the trials. These show that for CO_2 values up to about 12 per cent., only a slight trace of CO is present, while for values from about 12 to 16 per cent. large increases in CO may be expected up to 1.5 and higher. Hence, for running conditions as found at the laundry, it would seem unwise to raise the CO_2 much in excess of 12 to 13 per cent.

TABLE 5

Trial No.	Flue Gas CO_2	Flue Gas O	Flue Gas CO	Per Cent. Air Exc.	Per Cent. Flue Temp.	Per Cent. Loss Due to Prod. of Combustion	Loss Due to Exc. Air	Loss Due to CO	Per Cent. Black Smoke
1	15.20	3.46	0.39	19.4	745	12.71	2.11	1.40	13.1
2	14.20	5.22	0.40	33.6	705	11.95	3.42	1.49	17.1
3	13.50	5.50	0.09	34.9	664	11.65	3.54	0.30	5.0
4	14.70	2.30	0.70	12.0	711	12.69	1.28	3.54	15.0
5	12.40	5.51	0.05	34.4	710	11.99	3.51	0.24	12.7
6	12.10	5.20	0.15	31.6	657	11.42	3.13	0.66	13.8
7	10.84	8.32	0.13	65.2	450	7.77	3.99	0.63	
8	12.95	5.33	0.40	33.0	466	6.92	2.02	1.61	
9	11.97	4.52	0.91	26.3	485	6.91	1.57	3.53	
10	14.60	2.70	0.25	14.3	687	11.19	1.37	1.29	15.0

TABLE 6

Flue Gas Per Cent. by Volume

CO_2	O	CO
10.0	9.0	0
12.4	6.4	0.1
13.0	5.8	0.2
15.0	3.1	0.5
16.0	1.0	1.50

For Trial 7 the CO_2 ranged from 9 to 13 per cent. with an average of 10.84 with CO ranging from 0 to 1 per cent. averaging 0.13. The flue-gas conditions, as might be expected, ran a little better during the first half than during the latter half of the trial, due in part to change in firemen, the one for the last half tending to carry a thinner fire.

Trial 8 gives good CO_2 results with 33 per cent. excess air, but shows an increase in CO, rising to about 0.4 per cent.

Trial 9 is given to bring out a state of combustion which may prevail where a comparatively low value for CO_2 is obtained (12.95 per cent.) even with a low percentage of oxygen (4.52) giving a low percentage of excess air (26.3 per cent). The high percentage (0.91 per cent) of CO obtained shows an unequal air distribution, due probably either to the clogging of the air passages caused by the high caking tendencies of the coal or by the liberation of gusts of volatile gases which failed to be fully burned in the combustion chamber before reaching the cooler surfaces of the boiler tubes. The last kind of coal (Pitts. No. 8) used at the laundry and the coal used at the university, especially that for trial 9, had higher caking properties than either the West Virginia Splint or the Hocking coal, which would seem to indicate that a caking coal was harder to manage in this class of stoker than a noncaking or free-burning coal.

TABLE 7. OVERLOAD CAPACITY AND EFFICIENCY

Trial No.	Per Cent. Rating	Equiv. Evap. per Lb. Actual Coal Lb.	Equiv. Evap. per Lb. Comb. Burned Lb.	Efficiency Boiler, Grate and Furnace Per Cent.	Coal per Hr. per B.hp. Lb.	B.t.u. Actual Coal	Radiation, Etc.
7....	126	8.49	10.75	67.6	4.06	12,184	12.78
3....	149	8.03	10.97	69.9	4.31	11,164	5.65
4....	165	7.31	10.17	67.1	4.73	10,570	8.39
6....	167	8.24	10.09	63.5	4.21	12,582	12.93
2....	171	9.26	11.86	72.5	3.72	12,375	1.25
1....	172	9.15	11.02	69.9	3.78	12,697	7.19
5....	176	8.25	10.17	66.3	4.19	12,067	9.75
8....	167	8.71	.....	65.8	3.96	12,830	12.48
9....	186	7.96	10.11	59.0	4.34	13,120	15.82
10...	203	8.95	10.68	68.1		12,744	11.41
				Av.	4.15		

Table 7 contains the average results for the combined boiler, furnace and grate efficiencies at overload capacities for the nine trials. The percentage of rating for Trials 1 to 7 varies from 126 to 176 per cent., with more than half the trials averaging about 165. At the laundry the combined efficiencies, with one exception, range from 66.3 to 72.5 per cent. The trials showing the lowest efficiencies were those where Pitts. No. 8 coal was used, which gave the most trouble from clinkering and which also seemed to be a higher caking coal than the other two kinds used. The extreme fluctuations in the load at the laundry made it difficult to regulate the thickness of the fire, and this fact emphasizes the need of maintaining a boiler test for at least ten hours unless the load should remain fairly uniform.

Trial 7 shows a lower efficiency (67.6) at the small over rating than was to be expected from the trials preceding. The percentage of unburned coal remained about the same, but a greater excess air was carried and a higher probable loss because of radiation is to be seen, due to greater exposed radiating surface.

Trials 8 and 9 were maintained for percentage ratings of 167 and 186 respectively, but the combined efficiencies obtained were low and the highest contributing factor to these low results appears to be the high unburned coal loss (10.17 per cent.) resulting from the too frequent dumping of refuse. The CO loss is also high in Trial 9, showing restricted and unevenly distributed air supply, notwithstanding the high

tuyere box pressure (2.76 inches) maintained. Probably 6 per cent. at least might have been saved from these two sources alone.

The radiation losses from the trials at the laundry are somewhat variable, ranging from 1.25 to 12.8 per cent. Throwing aside the lowest result, which seems to be in error, the average radiation loss is 8.8 per cent. as compared with 12.6 per cent. for trials 7 and 8.

The coal fired per hour per boiler horsepower (Table 7) runs from 3.72 to 4.73 pounds, averaging 4.15 pounds for the nine trials.

As might be expected, these results do not give the high efficiencies looked for from a boiler trial where the load is carefully regulated, where the flue-gas conditions are carefully watched and the combustion is so adjusted as to reduce the furnace losses to a minimum.

At the Detroit-Edison tests of 1911,* Dr. Jacobus was able to get, on a Stirling boiler of 2365 hp. rating equipped with a 26-retort Taylor stoker, efficiencies of 80 per cent. for 100 per cent. rating and 76 per cent. for 200 per cent. rating, for 24-hour trials, using 14,000-B.t.u. coal. The loss due to unburned coal running about 3 per cent. as compared with 4.4 per cent., the average unburned coal for Trials 1 to 7 inclusive, the radiation loss, necessarily much less than for the small units, averaged 2.81 per cent. as compared with 8.8 per cent. and 12.6 per cent. for the three-retort unit. On the large unit, the coal burned per hour per boiler horsepower averaged 3.11 lb. (14,000 B.t.u.) as compared with 4.15 (12,000 B.t.u.), or 3.56 pounds (14,000 B.t.u.) per hr. per boiler horsepower for Trials 1 to 9 inclusive.

A report on eleven other trials† made in 1913 for the National Tube Co., Kewanee, Ill., on a 600-hp., four-pass Edge Moor boiler, with a seven-retort Taylor stoker, gave combined efficiencies ranging from 80 per cent. at boiler rating to 69 per cent. for 200 per cent. rating. These trials were carried on for periods of eight hours, and because of the careful supervision and management during the trials, the efficiencies agreed closely with those of a 72-hour check run made later.

At the university some years ago, a combined efficiency of 71.5 was obtained on a 100-hp. Babcock & Wilcox boiler with a stationary top feed, hand-fired grate using Pocahontas coal. This test, however, and also the others just mentioned, were conducted with the greatest possible care, and the precautions thus taken would account for the excellent results obtained.

The tests discussed in this paper, made as nearly as possible under average daily operating conditions, would seem to indicate that a fairly high overall efficiency for this type of stoker is within reach of the average fireman. His interest will be greatly aroused and his efficiency will be proportionately increased by the use of some of the boiler-room indicating appliances such as the indicating flow meter and the flue gas and draft recorders.

In conclusion, it may be said that the chief controlling factors influencing the efficiency of a Taylor stoker at overload capacity appear to be:

1. Size of the unit.
2. Percentage of overload.
3. Character of coal.
4. The use of indicating boiler room appliances.
5. The intelligence of the fireman.

The factor of most importance is, without doubt, the degree of intelligence which the fireman possesses and the interest he takes in improving the operating conditions.

*Trans. A. S. M. E., Vol. 33, p. 582.

†Power, Feb. 24, page 285.

Steam-Boiler Construction and Inspection*

By H. A. BAUMHART

A boiler must be so designed that the shell or drum, including the covering strips at the longitudinal joint, can be formed to a true circle to avoid bending under pressure. This would exclude the lap-seam form of construction. The lap-seam form of joint should be eliminated, excepting in shells of small diameter and comparatively low pressures. Flat surfaces requiring staying or bracing are a source of considerable anxiety to a boiler inspector. Solid stay-bolts are commonly used. The factor of safety recommended for such bolts varies from 7 to 8, according to the quality of material used. If stay-bolts were subjected to a tensile stress only, failure would rarely occur. There is, however, another condition of service in connection with stay-bolts to be recognized, that is, unequal expansion and contraction. When the fires are lighted the inner box plate or tube sheet becomes heated first, and expands in advance of the outer plate. Later, as steam is generated, the outer plate expands up to or beyond the inner plate, thus making two bends of the bolts at each operation. It is true that the bend is only slight, but it is of sufficient frequency to break the bolt, and, in some cases where the fireboxes are of considerable length, within a month's time. The outer plate is usually thicker than the inner and holds the bolt more firmly, causing it to bend and ultimately to break where joined to the outer plate.

There is another serious problem in connection with stay-bolted surfaces. The stress due to unequal expansion and contraction causes movement of the bolt in the hole of the outer sheet, producing corrosion or flaking off of the material at the inner end of the stay-bolt hole until frequently the riveted end of the bolt is the only portion holding. In lighter material this stress sometimes produces slight bending of the plate with such frequency that it produces cracks extending in every direction from the stay-bolt holes. These cracks are visible only from the inside, and because of the limited space they cannot be seen without first removing some of the bolts, and, therefore, may not be detected until leakage appears. The best remedy for such a condition is a flexible bolt. The hollow bolt is an improvement only because leakage will appear when the bolt is broken, and, therefore, is recommended by some inspectors in preference to the solid bolt.

The heads for drums or domes should be of the convex, or what is commonly known as bumped, type. Care should be exercised in forming the head in order to obtain a true curvature and to avoid the possibility of the head bending under pressure. Such a head having a manhole should be made of material not less than ⅛ in. heavier than the blank head in order to give it sufficient stiffness to avoid bending, because of the manhole opening. For extremely high pressures, such as carried on air-storage tanks operating under 1000 lb. per square inch, the heads should be made cone shape. This shape is stronger than the bumped head, but more expensive to construct, and is seldom used excepting for extremely high pressures.

The question of bracing flat heads is also an important one and care should be had to see that the braces are so distributed that each will carry its share of the load. It is also important to attach the braces to the heads or shell plate to avoid double thickness of material on the heating surface.

Until about 1880, iron was used exclusively for boiler plate. A very high grade of iron plate was manufactured, having a tensile strength varying from 42,000 to 45,000 lb.; in a few cases 50,000 lb. was obtained. It was not readily susceptible to attack by acids and, therefore, its deterioration, even in locations where the water was contaminated, was comparatively slow as compared to modern steel. Steel boiler plate replaced iron several years ago. Great care is necessary in the preparation of steel for boiler plate.

Other ingredients besides carbon are sulphur and phosphorus, but only traces of these two can be permitted in the best quality of boiler steel. The more injurious of these is phosphorus. Boiler steel must be made by the openhearth process. The percentage of phosphorus should not exceed 0.03 per cent. and sulphur should not exceed 0.04 per cent. for the best grade of steel. A maximum tensile strength of 60,000 lb. per sq.in. is usual, and 54,000 lb. is preferable. A certified copy of the mill test report should accompany each plate entering into the construction of a boiler.

The use of cast iron for any of the pressure parts of a

*From a paper presented before the Ohio Society of Mechanical, Electrical and Steam Engineers, June, 1914.

steam boiler is not recommended. Cast steel or forged steel should be used wherever possible.

The best material may be so handled by an incompetent workman as to render it unfit for service. This is especially true in connection with forming the shell plate and butt straps. If the shell plate and straps are not formed to the proper circle, either by a rolling or a pressing process, and the boiler maker attempts to make the proper fit with the aid of a sledge hammer, fractured plates will probably result. Such cracks may be so slight at first as to defy detection even by the aid of a glass, but they will extend in dangerous proportions after the boiler is in service.

No rivet hole or tube hole should be punched; they should be drilled. State and municipal laws permit the holes to be punched small and reamed to size, which is only a compromise arrangement. My advice when ordering a boiler would be to insist upon having every hole drilled from the solid. While it is true that reaming does remove a considerable portion of disturbed molecules, it does not remove all of them.

The caulking edge of the plate and butt straps should be prepared on a planer. Bevel shearing should not be permitted because it produces the same bad result as punching a hole in the plate; that is, it disturbs the material for a considerable distance from the edge, producing numerous minute cracks, always an element of danger.

There is a vast difference of opinion among mechanical engineers and boiler manufacturers with reference to the proper factor of safety. Modern rules adopted by the various states and by the provinces of Canada require a minimum factor of safety of 5, the United States marine rules not less than 4. In my judgment a factor of safety of 5 should be the minimum. To illustrate this point more clearly, I would refer to a record relating to a test of material and which is a part of the records of the American Society of Mechanical Engineers. At a factor of safety of 2, the number of repetitions of stress required to produce rupture was 20,000; at a factor of safety of 2.5, 210,000; at 3, 700,000, and at 3.5, more than 1,600,000. It would therefore follow that boilers operated under a factor of safety of less than 4, because of the so called fatigue of metal under stress, should not be used. A boiler operating under 4 or less could be expected to fail many years before another boiler operating under 5 or greater.

The subject of a proper retiring age for boilers comes frequently to light and is a most fruitful source of controversy. Of course, there can be no question as to the propriety of condemning those boilers whose diseases are no longer curable, but there is at once the basis for a deal of argument when an inspector approaches the owner of a boiler with the statement that it must be replaced because of old age, especially if it is known to have all the apparent qualifications, except youth, for many additional years of service. In the past many curious properties have been attributed to old boilers; one of the most interesting was the notion that they could not explode violently. It was supposed that an old boiler would merely rupture, allowing the pressure to be relieved much as if the safety valve had opened. This idea was definitely disapproved many years ago along with many other fallacies and much popular mystery concerning boiler explosions.

We all know that the steel used in boiler construction will deteriorate with use; it undergoes a slow loss in strength and ductility. The process is hastened by the presence of a moderate excess of phosphorus. Deterioration of this character cannot be determined by the usual method of inspection. It is, therefore, difficult to state definitely at what time in service the boiler should be abandoned. This places a great responsibility upon the inspector. He must consider, in addition to the general appearance of the boiler, the conditions under which it has operated, and he must also make allowance for defects in the material which are not visible. Experience shows that boiler plate, subjected to the high temperature of the furnace, does deteriorate to the extent that after about twenty or twenty-five years' service, the boiler should (if we follow the motto "Safety first") be taken out of service. Because an inspector reports that he considers the boiler unsafe for further use, it does not imply that he can predict the day and the hour when it will explode; it does mean, however, that the factor of safety is too low, and to continue the boiler in service for any considerable length of time presents a hazard too dangerous to be undertaken.

A steam boiler explodes or fails from one cause only, and that is, the boiler or the part which fails could no longer resist the strain placed upon it. The applied pressure may be sufficient to rupture a sound boiler, or the boiler may have reached such a state of deterioration that the ordinary working pressure becomes an over-pressure. In the majority of serious explosions, the primary cause was due to the lap-seam form of construction.

Many accidents are due to overheating of the shell plate or tubes. The overheating may result from various causes. The common cause is a deposit of scale, sediment, oil, or a combination of oil and scale on the internal surfaces. The presence of oil or grease, although in moderate amounts on the internal surface of a shell plate or tube is dangerous, and, unless removed promptly, will result in a damaged or possibly an exploded boiler. Great care should be exercised to prevent oil entering a boiler.

By referring to the records of the Hartford Steam Boiler Inspection & Insurance Co., I find the following for the United States:

Year	Boiler Explosions	Persons Killed	Persons Injured	Persons Total
1911	499	222	416	638
1912	537	278	392	670
1913	499	180	369	549

The annual property damage is estimated at a half million dollars. The above records include boiler accidents of every description, some of which were of minor importance. We are much encouraged because of the great interest now taken by engineers everywhere insisting upon proper construction and inspection of steam boilers. In many locations boiler inspection is required by law. The situation, therefore, as regards safety is gradually improving. We have not yet reached the stage of no boiler accidents; such a condition will never exist. There will be boiler explosions as long as steam boilers are used. We have not yet reached the stage of perfection in the manufacture of material, neither have we reached perfection in the art of boiler design. We learn as much from the result of failure as from the result of success. Further experiences in the operation of steam boilers may teach us that some radical change in design or character of the material is required to make boilers that will not explode under constantly increasing pressure and temperature.

Another condition which must be considered in connection with the safe operation of steam boilers is their care and management. It frequently happens that a boiler explosion, or some other calamity resulting in loss of life, occurs where it is least expected. This proves that, in spite of the advanced precautions that science has provided, reliance must still be placed in human intelligence and faithfulness to a large degree and that sometimes these fail.

It is recommended that boiler owners and users provide every possible method of safeguarding human life and property by purchasing only such boilers as have been thoroughly inspected during construction and by seeing that they are also inspected during the life of the boilers. Fortunately, in the state of Ohio such conditions now prevail. It also devolves upon the owner or user of a boiler to select only such persons as are fitted to care for them.

Ohio Society Spring Meeting

The spring meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers was held at Sandusky, Ohio, June 11, 12 and 13. On Thursday evening the papers upon "The Taylor Stoker Operating under Average Conditions," by Horace Judd, and "Steam Boiler Construction," by H. A. Baumhart, to be found on pages 897 and 900, were presented and discussed. On Friday evening a paper was to be presented on the "Uniflow Steam Engine," by James H. Debes, chief engineer of the C. & G. Cooper Co. In Mr. Debes' unavoidable absence, A. C. Ruhl, who is in charge of a plant at Port Clinton in which there is one of the Cooper uniflow engines, told of his experience with it. There had been some difficulties, but the engine was now running satisfactorily and with the straightening out of the condenser and cooling water conditions, will undoubtedly run with remarkable efficiency. They had, upon a recent test, obtained a performance of 11¾ lb. of steam per indicated horsepower with a 24-in. vacuum, 170 lb. pressure and 30 deg. of superheat. The engine is 34 in. diameter, 36-in. stroke, and runs at 125 revolutions.

Embury A. Hitchcock, power sales engineer of the E. W. Clark & Co. Management Corporation, gave an interesting lecture on the "Power Plants of the South," illustrated by lantern slides. A. C. Rogers, superintendent of heating of the Toledo Ry. & Light Co., questioned a statement made by F. W. Ballard, chief engineer of the municipal electric-light plants at Cleveland, at a previous meeting, that they were making 1000 lb. of steam for 10c. This would hardly pay the coal cost, and he objected to such statements going out with the apparent sanction of the society. A discussion of the statement is promised for the next meeting.

Visits were made to the plants of the Libbey Glass Co., the Sandusky Gas & Electric Co., the Lower Lakes Docks Co., the quarries of the Breakwater Construction Co., at Johnson Island, the new filtration plant, and the pleasure resort at Cedar Point.

Master Steam and Hot-Water Fitters Convention

The twenty-sixth annual convention of the National Association of Master Steam and Hot-Water Fitters was held at Atlantic City, June 10 to 13, inclusive, with headquarters at the St. Charles Hotel.

Wednesday was taken up by the meetings of the board of directors, the committee on standardization and committee on trade relation. The first general session of the convention was called to order at 10:30 o'clock Thursday morning by President Edward B. Denny. Mayor Riddle opened a "canned speech of welcome," and got the one intended for the plumbers' convention. He qualified the error by stating that the prices of the steam fitter and the plumber were so nearly alike in high-rate charges that his little mistake would make no difference.

President Denny, in his annual address, extended a welcome to the members of the convention, to the ladies, the manufacturers and their representatives, and the members of the trade press.

In speaking of the work of standardization President Denny said that in connection with the schedule of flanged fittings and flanges that at one time it seemed that the years of effort to establish a uniform schedule might be entirely nullified by an opposing combination. This was prevented by the committee in arranging for a conference in Washington, D. C., of all parties interested, at which conference a basis of agreement was reached eventually resulting in the final adoption of the uniform schedule known as the 1915 U. S. Standard Schedule, leaving the name in controversy, however, some of the committee of the American Society of Mechanical Engineers desiring to call it the "American Standard" schedule. The standardization committee is still at work on the problem of radiator valves, boiler ratings, lock-shield air valves, uniform height of radiator outlets and other items of importance to the master steam fitters.

The president referred to subcontracting and of the conference committee's efforts to subdue and destroy the evil, and to the success in securing separation of mechanical equipment from general contracts in state, county and municipal buildings in several states. He stated that bills providing for such separation are pending in the legislatures in other states.

According to President Denny, there is more or less complaint about the sale of material by the manufacturers and dealers direct to the consumer, and about the losses and annoyances arising from subcontracting; but the one great evil is the low competitive bidding, which eliminates all profits on contract work. A large proportion of the contract work done by the master steam and hot-water fitters is at prices which do not repay overhead charges, which condition in many cities has caused the more competent and responsible master steamfitters to abandon the business, and many others would gladly do so if they could retire without debt.

The speaker was not hopeful of business conditions, the most apparent cause for depression to pipe fitters being the practice of manufacturers and dealers of supplying brains and capital for men who have had no business training and starting them in their career as destructive master steamfitters, hundreds of men whose only qualification is their ability to cut, thread and screw pipe. It was hoped that the financial losses which are sure to follow will finally result in its discontinuance. If jealousies and animosities give way to friendliness and helpfulness, fair and equitable prices would be placed upon all work, whether contracting or jobbing, and the manufacturers and dealers would recognize the master steamfitters as necessary middlemen, entitled to a profit on the goods handled, and would cease to swamp the business with incompetent and irresponsible master steam fitters. The remainder of the session was taken up with the reports and appointment of committees.

DELEGATES AND GUESTS OF THE NATIONAL ASSOCIATION OF MASTER STEAM AND HOT-WATER FITTERS, IN CONVENTION AT ATLANTIC CITY, N. J.

The afternoon session convened at 2:30 o'clock and was devoted to committee reports. The report of the conference committee regarding the evils of subcontracting had, among other things, the following statements which were used in the two interviews with the committee appointed by the American Institute of Architects, with the result that they passed a resolution condemning the practice. In the May 20, 1912, meeting the following was presented:

It costs the trade, as a whole, more to estimate for general contractors than is realized from the profits made on all the work obtained from them. The actual cost to each steamfitter or plumber will average not less than ½ per cent. on the amount of an estimate. It costs each not less than $10 to figure the cost and to prepare and submit an estimate for a $2000 contract. When such estimates are made direct to the owner, the average number of bidders will be five, in

which case the cost to the trade will be $50 for estimating; but if the same work is included in a general contract, there will be an average of five general contractors bidding on it, each of whom will get from five to ten estimates from plumbers and steamfitters. If the average number of such estimates is but twenty-five, the cost to the trade will be $250.

The average profit on a $2000 contract does not exceed $200. It will be seen from these conservative figures that while the profit on such a contract made direct with the owner may amount to $190, the profit to the trade as a whole is but $150 after deducting the cost of estimating, but the same contract taken through a general contractor actually costs the trade $50 more for estimating than the successful subcontractor can make on it.

Estimates given to general contractors are not, as a rule, fairly handled. No provision is, or can be, made for the estimates being opened in the presence of bidders and the awarding of the contract in accordance with fair competitive rules. Usually they are opened as received, by the general contractor or one of his employees, and the figures may easily be obtained by favored competitors. If the general contractor gets the work it is seldom that he awards the subcontract on the merits of the sub-bids he has received; either a favored party is offered the contract at the price of the lowest bidder or else new bids are obtained, often from new bidders, and not infrequently the lowest final bidder is induced to take the contract at a lower price by false representations as to the estimates of his competitors.

Many general contractors are unable to properly finance the work they undertake and depend largely upon their credit to carry it through. In this "credit" they include the subcontractor. Almost invariably the steamfitter's payments are delayed long after the general contractor has received them.

In many places the lawful provision made to safeguard the claims of building contractors is nullified and lost to the subcontractor who, in the event of failure of the general contractor cannot recover from the owner because there is no agreement between them.

The nature of the work is such as to justify and often necessitate direct contact with the owner, or his representative, the architect. The general contractor is not concerned in such changes and betterments as are often made clear to the practical artisan as the work proceeds and frequently an inferior installation is made because of the indifference of the general contractor who cares only to comply with the specification.

It is reasonable to conclude that the same work done through a general contractor will cost the owner more than if done directly for the owner. In some way the general contractor will get a profit. If it is made to seem that the building costs less by general contract, the owner may be sure that he is getting less in quality or quantity. No steamfitter or plumber will do the same work cheaper for the general contractor (with all the risk and disadvantages) than he would for the owner.

While the evils of subcontracting are generally recognized among the master plumbers and master steamfitters, and resolutions have been adopted by both national associations reprobating the practice, there is no power to compel the members to cut out such business. Many, however, refuse to figure for general contractors and among those who thus refuse are many of the most reliable concerns in both lines of business.

At the meeting held Nov. 12, 1913, the conference committee submitted additional arguments in part as follows:

"The interest in the matter of divorcing what may be considered 'the mechanical equipment of buildings' from the bid of the general contractor is national in its scope. The one feature which has occupied the center of the stage has been 'the abuses practiced by the general contract.' That these abuses, many in number and variety, exist, is generally conceded by everyone with the possible exception of the general contractor.

"There are other features, however, which must not be allowed to be totally eclipsed by this seemingly major feature. There are four principal parties to one of these contracts, as follows: The owner, the architect, the general contractor and the subcontractor.

"As a general principle, it will be admitted by all fair-minded persons that the rights of each of these parties should be recognized and should be secured.

"The rights of the owner and of the architect are usually clearly defined and secured in the terms of the contract.

"The rights and duties of the general contractor are clearly defined in this same instrument, but when it comes to the rights and duties of the subcontractor no reference is made, it being left to the general contractor to select his subcontractors and make with them the best possible 'dicker.'

"In the selection of his architect, the owner is usually influenced by the character of the man and that of the work that man has actually produced. Having made his selection the owner should be warranted in feeling that his interests are safe because he has placed his work in the hands of architects noted for these qualities. The plans and specifications are ready and the architect calls in the 'general contractors,' and for one reason or another he is often obliged to receive proposals from general contractors of whom, in some cases, he knows little and in other cases in whom he has little confidence. Is it fair to allow such a general contractor to select his subcontractor?

"In nearly every instance where this has been discussed architects have admitted the advisability and feasibility of adopting our suggestions with one exception. They claim that it is most important that building operations should be finished 'on time' and they seem to be a unit in the thought that this can be accomplished only by having the work done under one general contract.

"Responsibility should be placed where it belongs, not by the general contractor but by the architect; every party to the contract should be held to strict accountability for the performance of his part of the work. No man should be blamed for omissions or commissions which strictly do not belong to him, and the judge of all this should be the architect; the owner expects and is entitled to this from him.

"There may be other ways of correcting this evil, but just now only two ways occur to us. The first and better way is for the architects to adopt measures to that end.

"The second is for the subcontractors to stand together and absolutely refuse to submit estimates to general contractors."

In the evening the members and guests enjoyed a lecture, illustrated by motion pictures, on the manufacture of modern welded pipe from ore to the finished product, by Frank N. Speller, of the National Tube Co.

Friday's session was devoted to a report of the convention committee and a discussion of topics brought before it. The election of officers during the afternoon session resulted as follows:

President, John T. Bradley, St. Louis, Mo.; first vice-president, Juan A. Almirall, New York City; second vice-president, Frank G. Carthey, Salt Lake City, Utah; third vice-president, Edmund Grassler, Milwaukee, Wis.; Board of Directors, John F. Bradley, Missouri; Juan A. Almirall, New York; Edmund Grassler, Wisconsin; John E. Rutger, New York; Edward B. Denny, New Jersey; William H. Oakes, Massachusetts; N. Loring Danforth, New York, and Noble P. Bishop, Connecticut. Sargeant-at-arms, John C. F. Trachsel, Pennsylvania. These newly elected officers were then installed. Retiring President Bradley was presented by the members of the association with a desk inkstand of artistic design.

The last session was held on Saturday morning to dispose of unfinished business and for a discussion of such topics as might come before the convention.

New York State N. A. S. E. Convention

The nineteenth annual convention of the New York State Association of the N. A. S. E. was held in Rochester on June 11, 12 and 13. The Seneca Hotel was the headquarters. There were about fifty delegates in attendance. The several sessions of the delegates were held in the auditorium of the Armory Building, and in the main hall adjoining was the mechanical exhibit of the supplymen, where the newest devices, apparatus and sundries of all kinds were displayed. The hall was tastefully decorated and conveniently arranged.

At ten o'clock on Friday morning the convention was called to order by A. J. Ranton, chairman of the convention committee, who introduced the speakers. Mayor Edgerton welcomed the company to the city, and State President E. E. Pruyn responded. Interesting addresses were also made by City Engineer Fisher; James R. Coe, national president of the N. A. S. E.; R. M. Searle, and William J. Reynolds, past national president of the N. A. S. E.

On Friday afternoon the delegates and guests visited the plant of the Taylor Instrument Co., while the ladies took chartered cars for an afternoon of pleasure at Ontario Beach. In the evening at eight o'clock there was a theater party at the Lyceum.

The feature of the entertainment furnished was the performance given in the convention hall on Saturday evening. The Rochester City Orchestra supplied the music, and an enjoyable program was made up by the following gentlemen: Herbert Self, Peerless Rubber Manufacturing Co.; "Lagonda" Mustin, the Pittsburgh representative of that company; Billy Murray, Jenkins Bros., and Jack Armour, of "Power." During the evening Past National President William J. Reynolds presented to retiring State President E. E. Pruyn a handsome French clock, the gift of the delegates and supplymen. Mr. Pruyn made a feeling address of appreciation.

Following are the state officers elected for the ensuing year: Fred Felderman, New York City, president; William H. Aydelotte, vice-president, Niagara Falls; William Roberts, secretary, Yonkers; William Downes, treasurer, New York City; William H. Dolamo, conductor, Rochester; Edward G. Geib, doorkeeper, Buffalo; William Downey, chaplain, Brooklyn.

The exhibition was liberally attended and the following firm were represented:

EXHIBITORS

John A. Roebling's Sons Co.
Lagonda Manufacturing Co.
Albany Lubricating Co.
M. T. Davidson Co.
Jenkins Bros.
United States Rubber Co.
M. E. Wolff Co.
Geo. Van Vechten Co.
Genesee Boiler Works
Rochester Vacuum Valve Co.
Jacob Hauser
Peerless Rubber Manufacturing Co.
N. B. Falls Lubricating Co.
Garlock Packing Co.
Lunkenheimer Co.
Howe & Bassett Co.
Otis Elevator Co.
William Wilson
Greene, Tweed & Co.
Cling-Surface Co.
Strong-Hery Co.
Haverstick & Co.
Barr & Creelman
Boig & Hill
Luitweiler Pumping Engine Co.
The V. D. Anderson Co.
L. Ernst Sons
"Power"
B. Fanning
Rochester Railway & Light Co.
Barrett Manufacturing Co.
Ashton Valve Co.
United States Graphite Co.
Mark Union Co.
McLeod & Henry Co.
Griscom-Russell Co.
Crandall Packing Co.
Armstrong Cork & Insulation Co.
Rowe & Waddell
Dearborn Chemical Co.
H. W. Johns-Manville Co.
Keystone Lubricating Co.
Syracuse Faucet & Valve Co.
Cross Bros.
A. L. Covill
Wheeler-Green Co.
Rochester Electrical Contracting Co.
Taylor Instrument Companies
Weaver Hardware Co.
City of Rochester
Wm. Powell Co.
Quaker City Rubber Co.

PATRONS

Diamond Power Specialty Co.
Wicks Boiler Co.
R. T. Ford Co.
Murphy Iron Works
White Wire Works
S. J. Macey Co.
Natt, Bareham & McFarlane
Kingsford Foundry & Machine Co.
H. H. Babcock
Yates Coal Co.
Vacuum Oil Co.
Chamberlain Rubber Co.
Mathews & Boucher
Willsea Works
Sterling Oil Co.
W. H. Herriman Co.
Caffery & Evans
Schwalb Coal Co.
Dan. Sohn Machine Co.
Jenkins & Macey
John D. Foster Co.
C. Thayer
Sidney Hall's Sons
McClave-Brooks Co.
Rochester Motor Co.
W. A. Wilson Machine Co.
American Oil Co.
James Gilbert
Wm. Summerhays' Sons
O. L. Goodenough
C. A. Tuke
Judson Governor Works
F. B. Callister

Auburn was chosen as the meeting place for the 1915 convention.

To convert B.t.u. per pound of coal to calories per kilogram, divide the number of B.t.u. by 1.8; to convert calories per kilogram to B.t.u. per pound, multiply the number of calories by 1.8.

AT THE NEW YORK STATE N. A. S. E. CONVENTION, ROCHESTER, N. Y.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Lancaster & Jefferson Electric Co., Lancaster, N. H., will install a new boiler. Walter U. Colby is superintendent.

The Crum Quarry Co., engine room and boiler house at Bradford, R. I., was destroyed by fire June 2. Loss, $15,000.

The United Illuminating Co., New Haven, Conn., will construct a new power house at Grande Ave. and Haven St. The estimated cost is $90,000.

Plans are being prepared for the erection of a municipal electric-light plant for Bath, N. Y. The cost is estimated at $50,000.

At a recent election at Binghamton, N. Y., bonds for $148,000 for the installation of a municipal electric-light plant were voted.

The Middleville Electric Light Co., Middleville, N. Y., is in the market for a 50-hp. boiler and engine.

New equipment will be installed at the municipal electric-light plant at Emporium, Penn. A 150-hp. gas engine, a 2200-volt generator and a switchboard are included in the equipment.

SOUTHERN STATES

Explosion and fire destroyed the power plant of the Meridian Light & Ry. Co., Meridian, Miss. Loss, $25,000.

Plans are being prepared for the installation of an electric-light plant in South Fulton, Tenn. R. C. Houston & Co., Exchange Bldg., Memphis, are the engineers.

CENTRAL STATES

Bids will be received by the commissioner of purchases and supplies, Cleveland, Ohio, until June 26, for furnishing equipment for the municipal electric-light plant. F. W. Ballard is commissioner.

The board of education, Fostoria, Ohio, will issue bonds for $20,000 to improve the heating systems of the public schools.

According to press reports the Chicago City Ry., Chicago, Ill., will build a new substation at 8205 South Halsted St. The estimated cost is $30,000.

According to press reports the Jacksonville Ry. & Light Co., Jacksonville, Ill., will construct a power plant estimated to cost $75,000. W. B. Miser is superintendent.

Plans are being prepared by R. Messmer & Bros., 1004 Majestic Bldg., Milwaukee, Wis., for the construction of a power plant, heating and lighting systems for the Milwaukee County Tubercular Sanatorium, Milwaukee.

WEST OF MISSISSIPPI

It is reported that the Minneapolis General Electric Co., Minneapolis, Minn., will make extensive improvements to its plant. R. F. Pack is general manager.

H. A. Dalbey, Hopkins, Mo., will construct an electric-light plant at Hopkins.